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IN-SITU FIELD DATA GATHERING STATIONS

SAN FRANCISCO BAY-DELTA

SALINITY INTRUSION WITH NAVIGATION CHANNELS

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Contract No. DACW07-78-C-0049

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FINAL REPORT

Oct 78 - June 80

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To: Department of the Army
San Francisco District, Corps of Engineers
211 Main Street
San Francisco, California 94105

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16 January 1981

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Temperature, current speed and direction, optical transmissivity, electrical conductivity, and tidal stage were measured half-hourly at five three-level and one one-level stations between February 1979 and June 1980. The stations were located in the San Pablo Bay to Suisun Bay area, including Carquinez Strait, in Northern California. Their purpose was to learn more about the freshwater - saltwater circulation pattern and further verify the Corps' Sausalito-based hydraulic model of the San Francisco Bay - Sacramento-San Joaquin Delta region.

(continued)

20 (contd) The main report describes the system of instruments and the associated data processing programs developed to transfer the data from cassettes to nine-track tapes, to screen it and present it on fiche. Examples of various displays are included. Associated volumes contain calibration records and field reports. The data are in tabulations, plots, and other displays, on microfiche,

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IN-SITU FIELD DATA GATHERING STATIONS

SAN FRANCISCO BAY-DELTA

SALINITY INTRUSION WITH NAVIGATION CHANNELS

FINAL REPORT

Contract No. DACW07-78-C-0049

To: Department of the Army
San Francisco District, Corps of Engineers
211 Main Street
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From: Kinnetic Laboratories, Inc.
P.O. Box 1040
One Potrero Street
Santa Cruz, California 95061

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SUMMARY

Six hydrometric stations, utilizing moored instrumentation, have been operated for the San Francisco District, U.S. Army Corps of Engineers. These stations were located from San Pablo Bay up into the upper Suisun Bay. Data acquisition covered the period from February 1979 through June 1980. Operational aid was also furnished to the U.S. Geological Survey for an additional data acquisition period of July 1980 through January 1981.

Five stations were to be located on navigation pilings on the edge of the main channel, each with bottom, mid-depth, and near surface sensors to record tidal elevation, current speed and direction, salinity, temperature, and percent light transmission. An additional station was located in Grizzly Bay with one set of sensors at mid-depth for salinity, temperature, and percent light transmission. Data were collected at 30 minute intervals and recorded on digital cassettes for later computer processing.

Government-supplied instrumentation manufactured by InterOcean Systems, Inc. was used for this program. InterOcean Systems, Inc. was also responsible for necessary electronic repairs of the instrumentation during the duration of the program. Model 513D multiparameter data acquisition systems were provided including temperature, conductivity, and depth (tide) probes. Model 510-Tr turbidity probes were added, as were electromagnetic current probes provided by Marsh McBirney and integrated by InterOcean into the package. All signals were cabled to the surface into InterOcean Model 580 cassette data recorders installed along with batteries in weatherproof boxes on top of the navigation pilings.

During the two year period, no moored instrumentation was lost, but a surface recorder on the Coast Guard navigation piling supporting the San Pablo station was vandalized once. Stations were visited for instrument checks or for maintenance every two weeks and more often when instrumentation problems were encountered.

Overall data recovery was limited to 67 percent due to frequent but diverse electronic failures of both underwater instrumentation and surface recorders. This data recovery does, however, represent approximately 1.8 million data points. A second major problem encountered was that of data interrupts in the cassette recording system causing ambiguities in the time sequencing of data. To accomplish time marks on the cassette data tapes, it was necessary to resort to elaborate checking for time sequencing during construction of data files as well as an instrument retrofit.

Except for changes due to time sequencing checks and computer screening for spurious values, the data are now available in raw form. No interpretive quality screening has been done. The data are available at the San Francisco District, Corps of Engineers as tabulations, on single- and 9-track tape, and as microfiche in the form of multiparameter plots.

INTRODUCTION

This report summarizes the efforts of Kinnetic Laboratories, Inc. in satisfying the requirements of the contract for "In-situ Field Data Gathering Stations: San Francisco Bay Delta Salinity Intrusion with Navigation Channels" (Contract No. DACW07-78-C-0049). The contracted work consisted of a prototype data acquisition study of the San Francisco Bay-Delta region extending from San Pablo Bay through Carquinez Straits to Chipps Island in Suisun Bay. The period of contracted work was from July 1978 (Notice to Proceed) to September 1980, with actual data acquisition occurring in the period from February 1979 through June 1980. Operational aid was also furnished to the U.S. Geological Survey for an additional data acquisition period of July 1980 through January 1981.

The purpose of the study, as stated in Schedule "A" (Scope of Services) of the contract (Appendix 1), was to obtain a quantitative, detailed data base on salinity, temperature, and turbidity variants with tides and currents. The information is to be used by the government to evaluate the short- and long-term response times of the prototype for the purpose of further calibration of the physical hydraulic model of San Francisco Bay and Delta. The data by itself will also serve as a historic record of the hydraulics and estuarine mixing processes in this important part of the Bay system during this two year period.

Under the terms of the contract, the obligation of Kinnetic Laboratories, Inc., was as follows:

a) Install and maintain instrumentation suitable for gathering prototype data on San Francisco Bay-Delta;

b) Develop the necessary software to convert the data into the specified form as set forth in paragraph 3 of Schedule "A";

c) Furnish documentation of all required computer programs; and

d) Furnish the results to the government in the form and at the times set forth in Schedule "A", and furnish all necessary personnel, facilities, equipment, materials, and transportation to perform the work described therein in a professional manner.

This report documents the fulfillment of these obligations by Kinnetic Laboratories, Inc. and the successful completion of the prototype data acquisition study. In the first section, field operations (including instrumentation, station locations, mooring design and routine servicing procedures) are described. Discussion of actual field proceedings throughout the course of the study follows, as well as reports on special studies undertaken to calibrate the instruments. In the data processing section, software developed both under government specification and in response to unanticipated hardware problems is described and the data processing procedure outlined. A brief overview of actual data recovery is given in the Results section. Recommendations helpful to future studies are also included.

FIELD OPERATIONS: DATA GATHERING

Description

The data gathering portion of the study involved establishment of stations, installation of moorings, deployment of instrumentation for taking observations and recording data, and procedures for maintaining and servicing the equipment. Measurements of salinity, temperature, current speed and direction, turbidity, and pressure (tidal heights) were taken with modern electronic oceanographic probes. Information was recorded at half-hour intervals onto cassette tapes to be later input into computer data processing systems.

Equipment and Instrumentation

The electronic data-gathering and recording equipment was furnished by the government as set forth in the contract. Original specifications for the instrumentation called for precision of parameter measurements as follows:

a) Tidal stages (±1 cm MLLW 10 sec sample)

b) Currents (magnitude ±0.05 m/s and direction ±5°)

c) Electrical conductivity corresponding to salinities of one to twenty-five parts per thousand (0.02 millimho/cm)

d) Temperature ±0.01°C

e) Turbidity (optical transmissibility) ±2% full scale

During contract negotiations, InterOcean equipment was selected jointly by Kinnetic Laboratories, Inc. (KLI) and by the Corps of Engineers. Major factors in the selection of InterOcean equipment included the multiple probes required, the high precision specified by the Corps for the various parameters (especially conductivity and temperature), and the Corps requirement for quick delivery which did not allot time for custom engineering and developmental testing. InterOcean already had such probes integrated into their on-the-shelf systems. Published specifications of their probes were also within those established by the government. Minor configuration and packaging modifications for the convenience of the application were also within InterOcean's capability.

The salinity probe provided by InterOcean was of the induction type. For this critical parameter, it was felt that the induction type of probe, rather than the electrode type, would be much more reliable over the intended two year program.

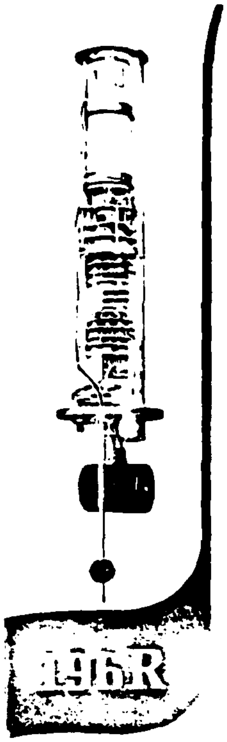
In addition, InterOcean could supply a rotor and vane type current sensor, but had also been using the electromagnetic sensor built by Marsh-McBirney with their equipment. Although the rotor and vane sensors of both InterOcean and other equipment suppliers were less expensive, it was felt that the electromagnetic type would produce better results because of biological- and debris-fouling problems. Severe fouling problems were encountered during the program. The government's decision to use the more expensive electromagnetic current sensors certainly increased the current data return over that which would have been taken with mechanical sensors.

Two other factors influenced the selection of InterOcean equipment. They were located relatively close to the study area such that any factory equipment repairs would minimize data loss, and they provided a one-year parts and labor warranty on all equipment.

With the information that was available at that time, InterOcean was the logical choice of equipment suppliers. Their final design is shown in Figure 1. Equipment descriptions and specifications are given in Appendix 10.

A choice of recording methodologies was available. Each probe could be hard-wired to a common recorder and data could be stored on tape for periodic retrieval, or the data could be telemetered from each station to a central collections and storage facility. The telemetering option has several advantages and disadvantages. The biggest advantage would be the prompt recognition of equipment malfunctions and therefore minimized loss of data. Other advantages would include: less frequent scheduled maintenance visits to each station; probably less data work-up time than required for individual tapes; and no loss of data from an entire station because of recorder failures. Some disadvantages of telemetering would include: the necessity to continue scheduling regular maintenance visits to the stations; the possibility of data loss due to unanticipated shadow zones, interferences, or weak signals during storms; the uncertainty of the central collection facility location and logistics of maintenance; the loss of all data in the case of the central facility failure; and the substantially higher cost of this option. Because of funding limitations, the first mode of data collection was chosen by the Corps of Engineers.

The recording format is shown in Figure 2, which was taken from the instruction manual supplied with the recorders. Since the conductivity and current sensors both operate by



- NO MOVING PARTS
- CURRENT SPEED AND DIRECTION
- CHOICE OF MULTIPLE SENSORS: C/S/T/D/Do/pH/Tr/Tide/SpIon/SV
- RELIABLE, STABLE, ENCAPSULATED SENSORS
- MODULAR CONSTRUCTION
- FOR MOORINGS WITH MAGNETIC TAPE RECORDING OR RADIO LINK
- FOR PROFILING WITH ON BOARD DIGITAL DISPLAY AND RECORDING

MODEL 196R

INTEGRATED OCEANOGRAPHIC AND WATER QUALITY MONITORING SYSTEM.

The InterOcean Model 196R permits the user to simultaneously obtain in-situ data from a wide choice of commonly measured parameters. Included are current speed and direction, using a no moving parts electromagnetic current speed sensor and a no moving parts flux gate compass. The user may also select any combination of the following parameters: Conductivity, Salinity, Temperature, Depth, Sound velocity, Dissolved Oxygen, pH, Turbidity, Oxidation Reduction Potential, and Tide measurement. Parameters may be selected initially or may be easily added later in the field by the user.

All data channels are transmitted via cable to a remote data display, data recorder, or radio telemetry link. Alternatively, the data may be recorded in-situ on a self contained, programmable digital data cassette recorder. The system may be used as a profiler, and it may be installed for long term monitoring projects.

The Model 196R is ruggedly built for the severest environments where corrosion, bio-fouling, and the threat of physical damage would greatly limit the use of mechanical rotor or impellor devices. The 196R uses a spherical, solid state, no moving parts, electromagnetic current velocity sensor. Two pairs of orthogonal electrodes sense the X and Y components of the velocity vector with a fast response. A flux gate compass is used to determine the orientation of the instrument with reference to magnetic north.

The excellent cosinusoidal tilt response of the spherical sensor permits the measurement of horizontal water velocities in the presence of vertical water motion. Large components of vertical water motion are often introduced by the orbital motion of a mooring or while making vertical current meter profiles. It is therefore extremely important for the sensor to reject the effects of vertical velocity in order to avoid large errors in the measurements of the true horizontal velocities.

This combination of rugged construction, no moving parts, fast response, and superior performance on a mooring or while profiling makes the 196R ideally suited to applications in hazardous environments and for long term installations without the need for frequent servicing and maintenance.

SPECIFICATIONS

Parameter	Range	Precision	Time Constant	Comments
Current Speed	0-300 cm/sec.	± 2 cm/sec.	1 sec.	Electromagnetic, no moving parts.
Current Direction	0-360	+ 2	100 m sec	Flux gate compass
Conductivity	0-65 mmhos/cm	± 0.02 mmhos/cm	20 m sec.	By induction, encapsulated sensor
Salinity	0-45 PPT	± 0.02 PPT	1.4 sec. stnd.	Automatic, continuous output
Temperature	-5 to +45 C	± 0.02 C	1.4 sec. stnd; 60m sec. opt.	Linearized thermistor, platinum resistance sensor
Depth	0-100m to 0-6000m	± 0.15% fs	60m sec.	Silicon Semi-Conductor pressure transducer
*Sound Velocity	1400-1600m/sec.	± 0.1m/sec.	30m sec.	Sing-around sensor
*Dissolved Oxygen	0-20 PPM	± 1% fs	5-10 sec.	Voltaic, polarographic membrane sensor, stirrer is not required
*pH	2-12 pH	± 0.05 pH	40m sec.	Sealed combination electrode
*Turbidity	0-100% trans. 0-200 JTU	± 2% fs	60m sec.	10 cm path length
*Specific Ions	- Request information for specific application			
*Redox	-400 to +400 mv	± 1 mv	100 m sec.	Platinum electrode

Power Input: ± 12 VDC ± 1% 100ma.
Signal Output: High level DC voltage for each data channel already scaled in engineering units.
* Also see detailed descriptions of sensors and electronics listed for Model 195M current meter and Model 513D probe

Pressure Case
Material: 316 stainless steel

*These probes are not a part of our moored meters.

Depth Capability:	(a) 1000 m.	(b) 7000 m.
Weight in Air:	(a) 23 kg.	(b) 45 kg.
Weight in Water:	(a) 10.5 kg.	(b) 33 kg.

Length: 76 cm. **Pressure Case:** 112 cm. overall **Diameter:** 15 cm.

Figure 1. Final Design Specifications of Moored Meters

Figure 2. Digital Cassette Recording Format
(see Notes for Figure 2, Following Page)

PROBE 1	0072	0016	1476	0784	0072	0016	1476	0790	
	0072	0016	1476	0793	0072	0016	1476	0795	
	0890	0012	0008	0296	0890	-0005	-0002	0295	
	0890	-0011	-0006	0295	0890	-0004	-0004	0296	
PROBE 2	-0802	3918	1424	0836	-0802	3918	1424	0836	
	-0802	3917	1424	0836	-0802	3918	1424	0837	
	0807	0021	0018	2448	0807	0007	0004	2453	
	0807	0014	0010	2453	0808	0017	0036	2450	
PROBE 3	-0592	3839	1429	0789	-0592	3839	1429	0789	
	-0592	3839	1429	0789	-0592	3839	1429	0789	
	0589	0010	0042	2743	0589	-0000	0017	2743	
	0589	0001	0010	2741	0589	-0001	0005	2741	
PROBE 1	0070	0014	1515	0763	0070	0014	1515	0774	
	0070	0014	1515	0780	0070	0014	-1516	0784	
	0890	-0008	-0009	0295	0890	-0005	-0012	0295	
	0890	-0005	-0002	0296	0890	-0004	0003	0296	
PROBE 2	-0802	3928	1442	0836	-0802	3928	1442	0836	1 GROUP
	-0802	3928	1442	0836	-0802	3928	1442	0836	
	0807	0020	0019	2461	0807	0007	0013	2460	
	0807	-0003	0001	2460	0808	-0002	0003	2461	
PROBE 3	-0592	3849	1444	0789	-0592	3849	1444	0789	
	-0592	3849	1444	0789	-0592	3849	1444	0789	
	0589	0009	0041	2741	0589	0007	0011	2741	
	0589	-0001	0004	2741	0589	0002	0008	2741	

CHANNEL:	1A	2A	3A	4A	1A	2A	3A	4A
	D	C	T	TR	D	C	T	TR
DATA FORMAT FOR PROBE WITH DEPTH	0095	3834	1400	0768	0095	3834	1400	0778
	0095	3835	1399	0784	0095	3835	1399	0789
	0890	0020	0010	0188	0890	-0000	0010	0188
	0890	0008	0009	0194	0890	0006	0003	0190
CHANNEL:	1B	2B	3B	4B	1B	2B	3B	4B
	+ID	Vx	Vy	Dir.	+ID	Vx	Vy	Dir.

	-ID	C	T	TR	-ID	C	T	TR
DATA FORMAT FOR PROBE WITHOUT DEPTH	-0592	3823	1404	0789	-0592	3823	1404	0789
	-0592	3823	1404	0789	-0592	3823	1404	0789
	0589	0012	0042	2739	0589	0004	0019	2736
	0589	-0002	0007	2736	0589	-0003	0008	2738
	+ID	Vx	Vy	Dir.	+ID	Vx	Vy	Dir.

NOTES FOR FIGURE 2 (from Operations and Maintenance Manual)

Recording Format

The format used to record the data on the cassette consists of eight lines in what is called a group, each line consisting of eight words.

Each group will contain four lines of data for each probe; lines one through four for one probe; lines five through eight for another. In each group of four lines, lines one and two will be identical in format as will lines three and four.

The first and fifth word in each line will be channel 1, the second and sixth will be channel 2, the third and seventh will be channel 3, and the fourth and eighth will be channel 4.

The first two lines will record channels 1A, 2A, 3A and 4A. The remaining two lines will record channels 1B, 2B, 3B, and 4B.

As an example, Figure 2 shows actual recorded data from a 680 MUX RECORDER INTERFACED WITH A MODEL 195SP PROBE RECORDER SWITCH. Selections are as follows:

CHANNEL SELECT	=	4
SCAN RATE (seconds)	=	30
REP. RATE (hours)	=	0.5
DATA SCAN SELECT	=	NA
DATA SETS/GROUPS	=	DATA SETS

This Recorder recorded channels 1,2,3, and 4 every 30 seconds. For this example, channel 1A is Depth or -ID(D/-ID), channel 2A is Conductivity (C), channel 3A is Temperature (T), channel 4A is Turbidity (TR), channel 1B is +ID, channel 2B is Current (V_x), channel 3B is Current (V_y), and channel 4B is Direction (DIR). Each line is read from left to right (D/-ID,C,T,TR) or (+ID, V_x, V_y, DIR). Each line represents one minute of recording time, i.e., 30 seconds for each scan of four (4) channels. This pattern repeats for eight lines, which constitutes a group of data. Then there is a break in the record, but not in time, and a new group is started.

Each word in a line is a four digit representation of the analog input voltage in millivolts, and each analog input is a representation of a sea water parameter expressed directly in engineering units. For example, a conductivity reading of 4756 means the conductivity is actually 47.56 millimhos/cm (see Table 4, p. 28).

Annotating the Record

When the Recorder is used with the InterOcean Systems, Inc. Model 195SP the records are annotated by the +ID and -ID parameters of each probe, allowing the user to correlate recorded parameters to the probe from which they were obtained.

setting up an electromagnetic field surrounding the probe, these would interfere with each other if measured simultaneously. Therefore, the recorders were programmed to activate half of the sensors at one level, then the other half at that level taking four readings two seconds apart for each parameter. The second and third levels were then activated in the same way. Therefore, measurements were taken at all three levels every half hour, as specified, within less than a one-minute period. To minimize battery drain, the probes were not powered during the interval between readings.

During the course of the study, it was found that a reading of real time on the data record would be a substantial aid in data processing. This is discussed in detail later in this report. Referring to Figure 2, the time mark is recorded as a substitute for the positive ID voltage during the interrogation of the first probe in the series of three. An example of this can be found in Appendix 9.

During the testing period prior to initial installation, it was discovered that three of the meters did not meet specification "b)" listed above. The government subsequently issued a contract modification (see Appendix 4) relaxing that specification to read: "b. currents (magnitude ±10% of full scale and direction ±5°)" in order to avoid further delay in the installation of the equipment in the field.

Station Locations

As specified in the contract, six stations were installed from which observations of the water column were taken. Stations 1 through 5 (San Pablo Bay to Chipps Island) were detailed in-situ stations, observing temperature, conductivity, current, and turbidity at three levels in the water column (near surface, mid-depth, and near bottom) as well as tide height measured at the bottom only. Station 6 (Grizzly Bay) was a limited in-situ station, taking observations of temperature, salinity, and turbidity at mid-depth level only.

Originally, three additional stations were planned, one full station in the San Joaquin River, another in the Sacramento, each slightly upriver from where they join at Pittsburg, and a limited station in Honker Bay. Funding restrictions necessitated the elimination of these stations.

Original specifications and plans for installation called for station locations as follows:

Station No.	Station Name	Station Location	Latitude	Longitude
1	San Pablo	San Pablo Bay, Pile "9"	38°02'32"	122°21'04"
2	Carquinez	Carquinez Strait, Pile "20"	38°03'20"	122°11'39"
3	Benicia	Suisun Bay above Benicia Bridge, Pile "6"	38°02'40"	122°06'30"
4	Pt. Chicago	Suisun Bay at Port Chicago, Pile "17"	38°03'56"	122°01'12"
5	Chipps Isl.	Suisun Bay at Chipps Island, Pile "27"	38°03'07"	121°55'57"
6	Grizzly Bay		38°07'04"	122°02'18"

Prior to installation, two of the original station locations were changed. Upon notification by the Coast Guard of a planned removal of Pile #17, it was decided to relocate station 4 (Port Chicago) at the next pile upriver (east), Pile #19. A reconnaissance visit to the planned station locations showed that Pile #20, the proposed site for station 2 (Carquinez Straits), was unsuitable due to shallow water depth and its apparent location in a reverse eddy during ebb tide conditions. The station location was moved west along the strait to the abandoned Southern Pacific Railroad grain loading docks. The final locations for all stations are as follows:

Station No.	Station Name	Station Location	Latitude	Longitude
1	San Pablo	San Pablo Bay, Pile "9"	38°02'32"	122°21'04"
2	Carquinez	Carquinez Strait, abandoned SPRR wharf	38°03'24"	122°12'11"
3	Benicia	Suisun Bay above Benicia Bridge, Pile "6"	38°02'40"	122°06'30"
4	Pt. Chicago	Suisun Bay at Port Chicago, Pile "19"	38°03'48"	122°00'05"
5	Chipps Isl.	Suisun Bay at Chipps Island, Pile "27"	38°03'07"	121°55'57"
6	Grizzly Bay		38°07'04"	122°02'18"

Station locations are shown in Figure 3.

Written authorization for the use of the Coast Guard navigational aids providing support for the stations was received from the Twelfth Coast Guard District, San Francisco. Permission to install the station at the wooden dolphin in Grizzly Bay and for the use of the abandoned SPRR dock at station 2 (Carquinez) was obtained from the Lands Transaction Unit of the State Lands Commission as well as, for the latter, Southern Pacific Transportation Company.

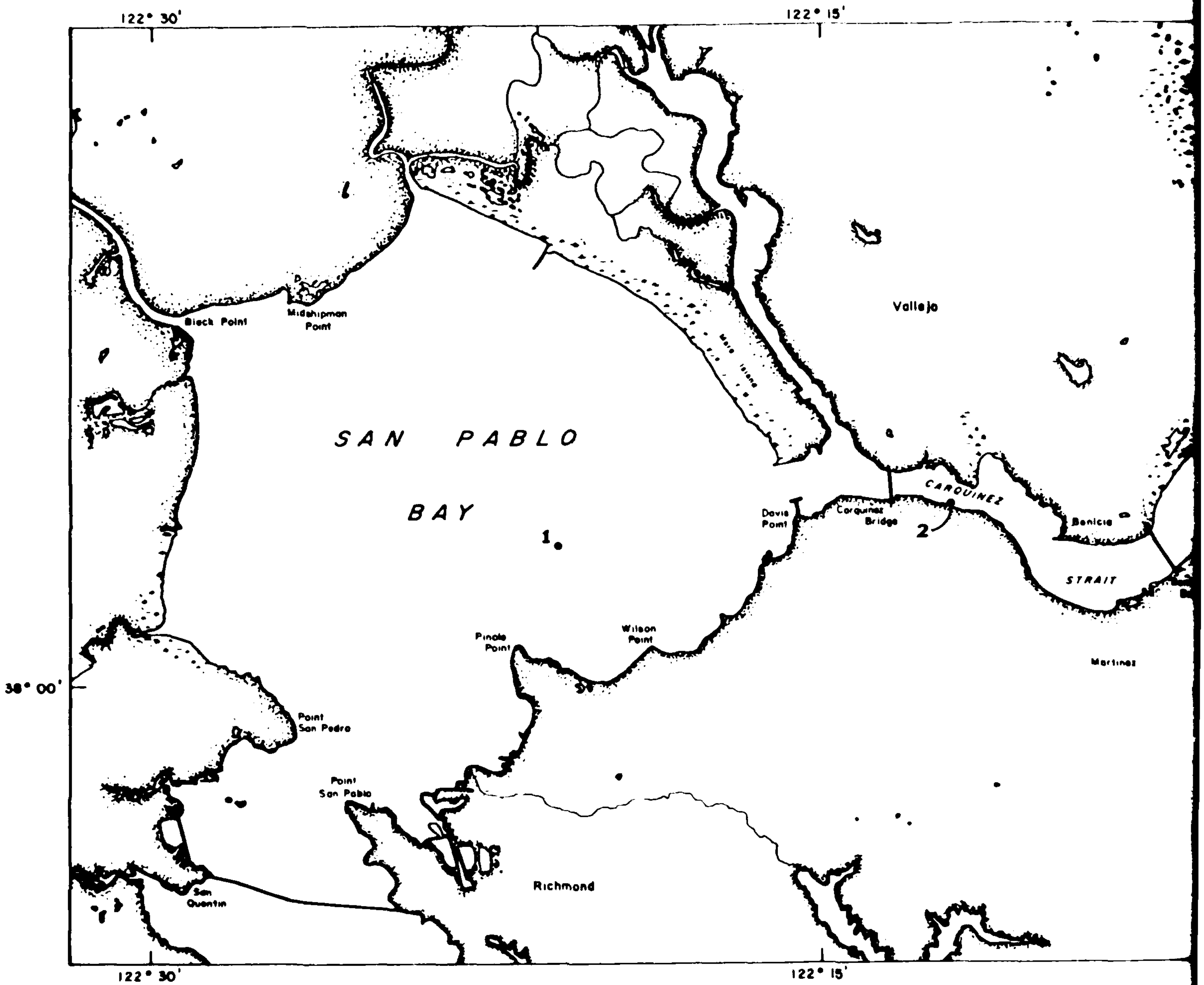
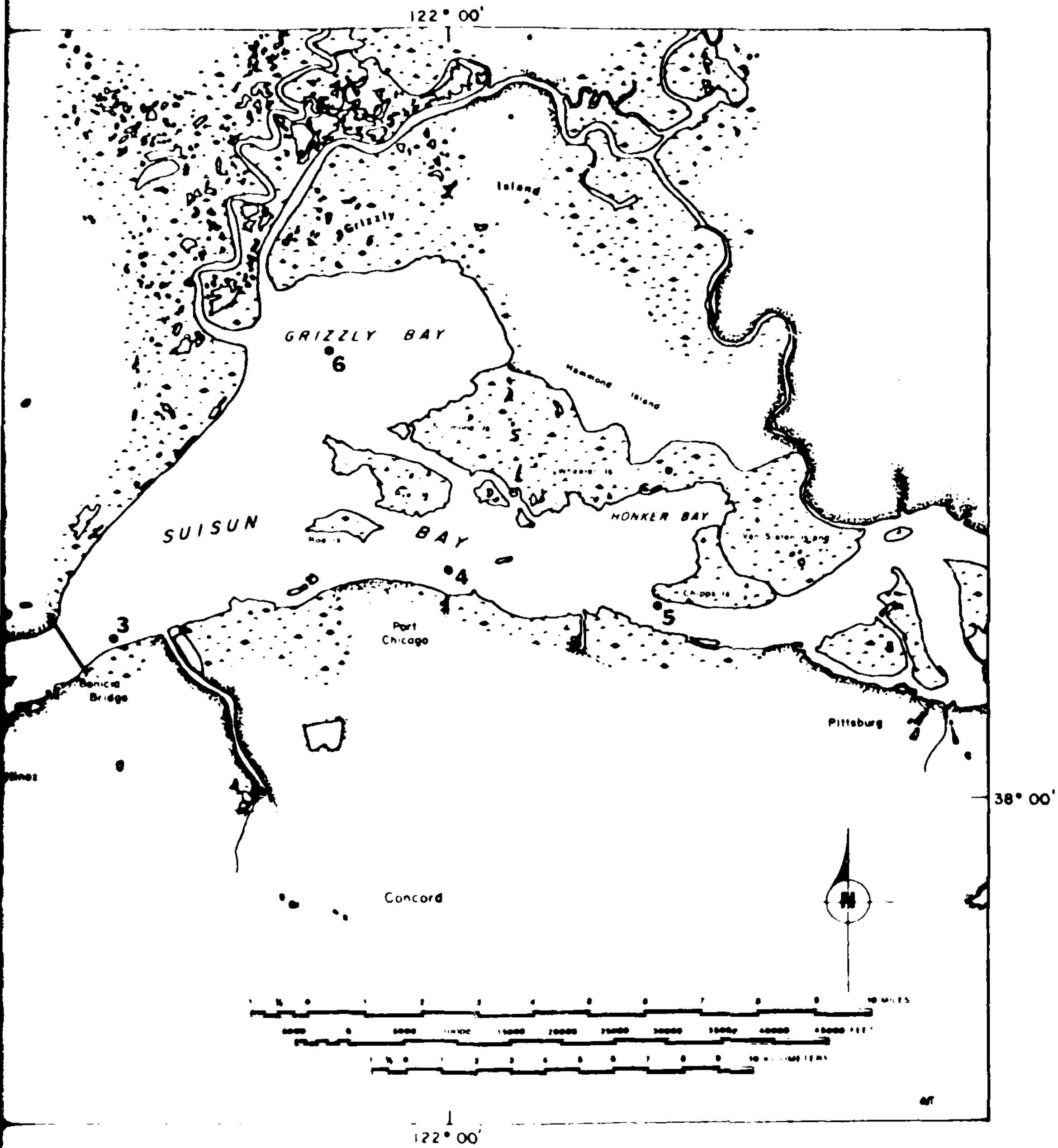


Figure 3. Station Location Map.


122° 00'
Island
Grizzly
GRIZZLY BAY
6
Hammond Island
SUISUN BAY
HONKER BAY
4
3
5
Port Chicago
Benicia Bridge
Pittsburg
38° 00'
Concord
122° 00'

ap.

The stations were designated to be placed on Coast Guard navigational aids or other similar pilings for several reasons. They were always in close proximity to the area's main shipping channel, around which the study centered. At the same time, they afforded a maximum amount of protection against damage to the expensive equipment from the heavy boat/ship traffic common in the study area. While mid-channel measurements would certainly be desirable, the risk to the equipment and logistical constraints of periodic servicing under these conditions ruled out this possibility. The configuration of the mooring, discussed in detail in the next section, was designed around these pilings (see Figure 4) in order to maximize servicing efficiency and protection of the instrumentation.

Mooring Design/Instrument Setup

At stations 1 through 5, the electronic monitoring instruments were suspended in the water from a "clothesline" consisting of a five foot stainless steel standoff, heavy metal winch, stainless cable, and bottom block with a sheave made of Delrin plastic connected to a railroad wheel anchor (see Figure 5). The meters were clamped onto one side of the cable and therefore could be raised or lowered by manually cranking the winch. The recorder and batteries were contained in a locked weatherproof box situated on the navigational aid platform.

Electronic cables to each meter passed from the recorder through a protective pipe which was clamped to the piling and extended underwater, even at low tides.

The system at Grizzly Bay was deployed differently due to different physical conditions. The mooring line consisted of stainless steel cable attached to the top of the wooden dolphin and anchored on the bottom by an automobile engine block. The meter at this station was suspended horizontally (because of the shallow depth at this station) by attaching a wire bridle to a ring on the mooring line at abut mid-depth (see Figure 6). A locked weatherproof box on top of the dolphin housed the recorder and batteries. The probe cable extended from the box down the mooring line to the meter.

The major instrumentation needed for the field stations is listed in Table 1.

Standard Servicing Procedures

Servicing of the equipment was carried out utilizing the KLI-owned RV Prophesy, a 30-foot diesel powered vessel, fully equipped with hydraulic winches and marine electronics.

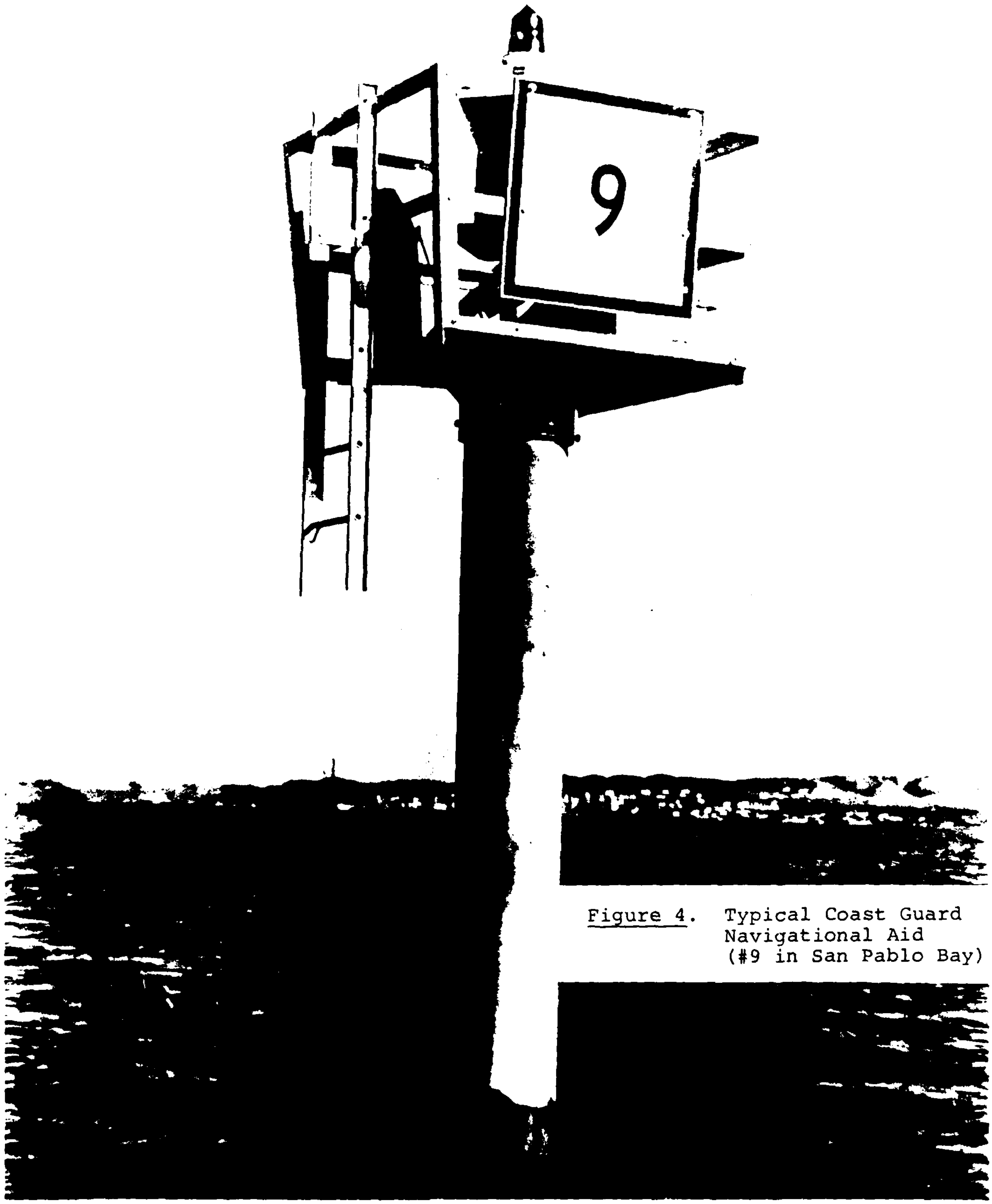


Figure 4. Typical Coast Guard Navigational Aid (#9 in San Pablo Bay)

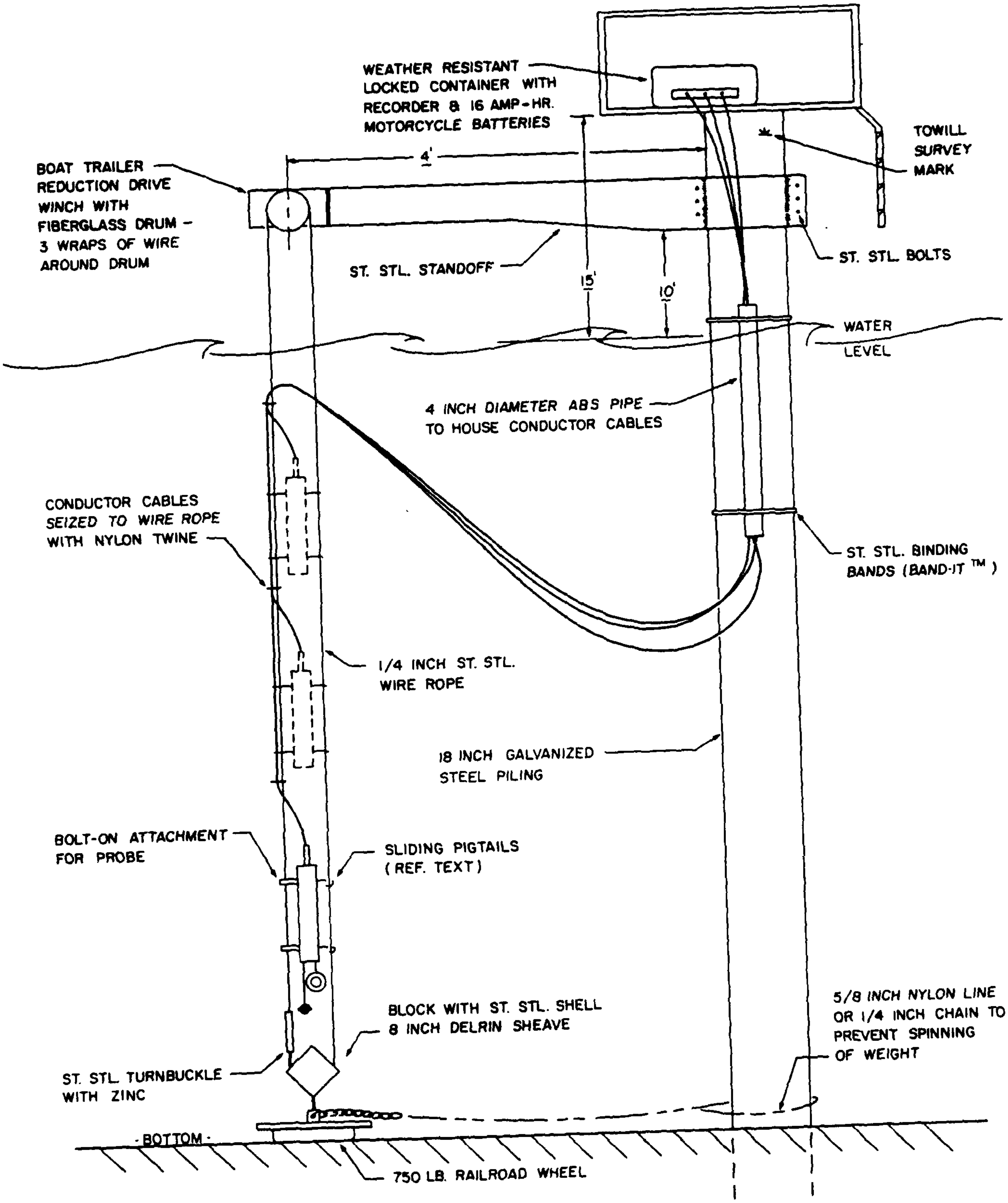


Figure 5. Mooring Design, Stations 1 Through 5

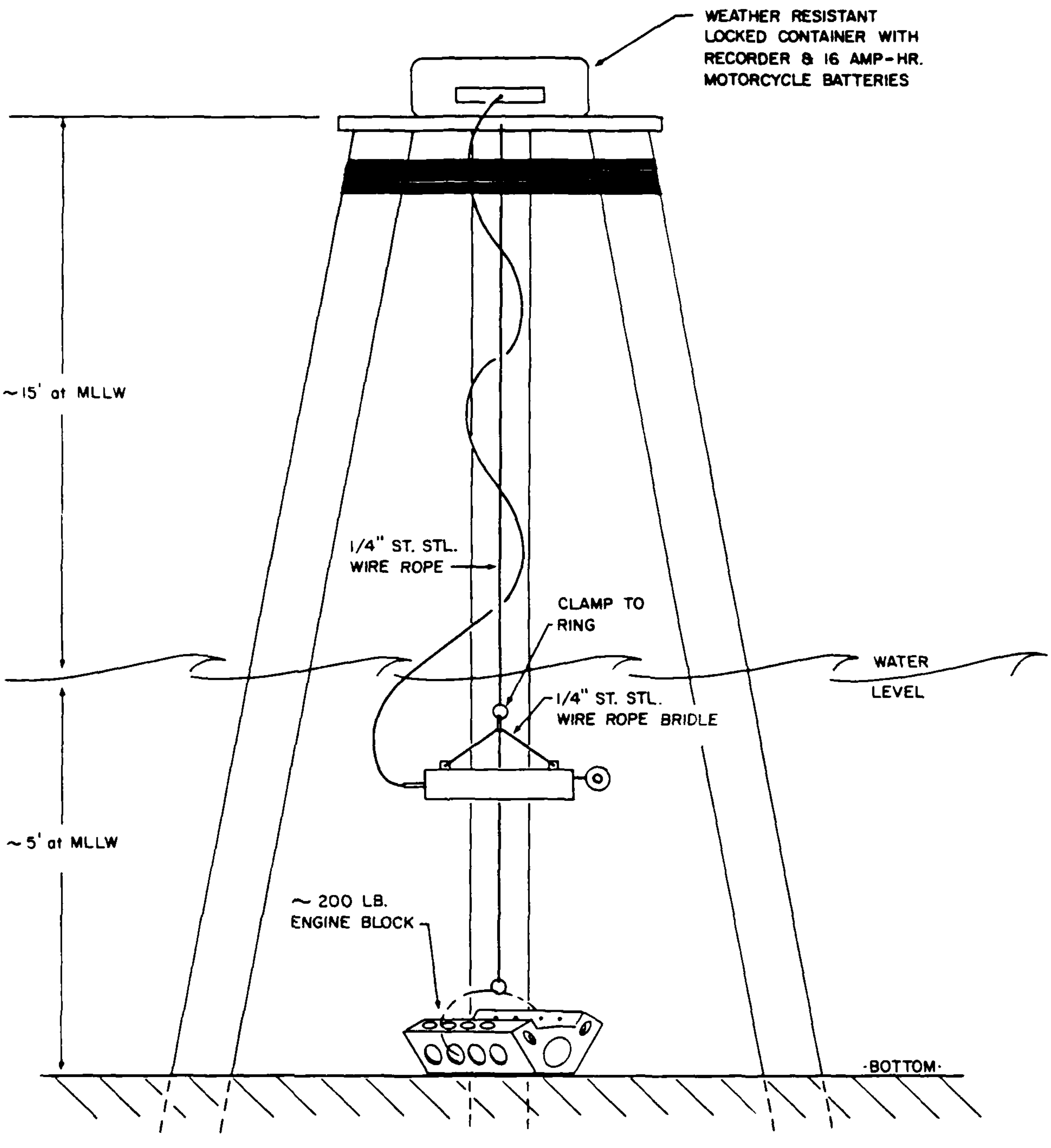


Figure 6. Mooring Design, Station 6, Grizzly Bay

Table 1. Major Instrumentation List
(Manufacturer: InterOcean)

Model Number	Description	No. per Station	No. of Stations	Total
513D-C	Multiparameter Probe with Conductivity	3 [+1 limited station (ltd sta)]	5 (+1)	16
513D-T	Temperature Probe	3 (+1 ltd sta)	5 (+1)	16
513D-D	Depth Probe	1	5	5
510-Tr	Turbidity Probe	3 (+1 ltd sta)	5 (+1)	16
500CS	Standard Conductivity Calibration	1	1	1
195R	Electromagnetic Current Meter Option for 513D	3	5	15
680	Digital Magnetic Tape Cassette Recorder, Programmable Timer with Case Option	1	6	6
---	Cabling	1 (+1 ltd sta)	5 (+1)	6
514D	Precision Digital and Analog Readout, Scan, 115VAC/12VDC Field Case	1	1	1
696	Digital Magnetic Tape Cassette Reader	1	1	1
---	Recorder Timer Circuitry (retrofit)	1	6	8*

*1 Master "clock", plus 1 per recorder, including the spare.

Note: This table does not include the spares which consist of one complete probe package, one recorder, several cables and cable components, one complete set of spare circuit boards for a probe package, and miscellaneous electronic components.

Original specifications called for monthly servicing of the equipment, but early in the planning stages, this was modified to two-week intervals to enable more timely discoveries of instrument problems. The first bi-weekly trip was (normally) a one- to two-day "fly-by." During the second monthly visit the "fly-by" procedures were repeated but in addition, the instruments were raised to the surface and examined for fouling, sensor integrity, and the condition of the sacrificial zinc anodes protecting each probe package as well as the mooring hardware. The time required for this was from one to three days. Additionally, if problems were encountered which were not solvable in the field, special additional trips were necessary.

Fly-by procedures included visiting all six stations and changing cassette tapes and batteries. Additionally, each meter was interrogated with the InterOcean digital data readout to determine the condition of all sensors. The interrogation was carried out by detaching the cable for each probe in turn from the recorder and connecting it to the readout. Real time data was then measured at each probe for each parameter. The information for each station was recorded on Data Logger Check Sheets, which also documented start and end times for the data cassettes and problems with meters or servicing. When recorder clocks were installed (October 1979), clock readings were also recorded. In February 1980, measures of tide heights at the interrogation time for each station were included in the monitoring procedure as well. When an interrupt in the monitoring occurred such that data were lost, a Data Interrupt sheet was completed to document this event. Meter and recorder removals and changes were also documented on this form. Ground truth data (salinity, current speed and direction, and temperature) were taken from the surface water as a check on the system operation at the same time as the readout values were being taken. Surface water samples were collected and brought back to KLI for salinity analysis. Surface water temperature was measured utilizing standard laboratory thermometers graduated in half-degree Centigrade increments. Direction of surface currents was determined using a hand-held compass, and flow was measured using a General Oceanics digital flowmeter. The data were recorded on Ground Truth Data Sheets. Examples of the field sheets used in the servicing procedure are found in Appendix 2.

Raising the meters at stations 1 through 5 was accomplished by manually cranking the winch and raising the meters one by one. Security was improved by removing the winch handle when the probes were replaced underwater.

The procedure at station 6 (Grizzly Bay) was different because of the different mooring described above. This meter was raised from the water by attaching a cable grip to the mooring line below water level and hoisting the meter and anchor assembly with a hydraulic winch onboard <u>Prophesy</u>.

Operations

The starting date for data gathering was initially set for 1 October 1978. The government-furnished equipment was not delivered in time to meet this deadline, however, and this combined with subsequent instrument calibration and check-out problems resulted in a delay of several months. Once installed, problems with instrumentation continued and in fact worsened throughout the data acquisition period. An overview of operational experience will be presented here, but more detailed chronological documentation of events beginning with initial receipt of the equipment may be found in Appendix 3.

The late installation of equipment was caused by a number of factors. The instrumentation to be moored was not delivered by the supplier until 15 December 1978. A contract modification was issued by the Corps of Engineers to cover this delay. Even though operational manuals were not received until early February, operational checks were conducted on all meters. Cassette tape-reading equipment was delivered in mid-January.

Since components had not been tested when assembled as complete systems, complete moorings (cables, meters, recorders) were assembled and subjected to long term (1+ week) testing as complete systems. A number of problems were discovered and rectified, such as two defective meters, turbidity sensors out of calibration, x,y axes reversed on some current meters, and one recorder giving variable data recording lengths upon reset. The most serious delay, however, was in obtaining probe calibration data from InterOcean, and in particular the results of tow tank tests carried out at facilities of Scripps Institution of Oceanography. When these tow tank results were finally received in late January, data indicated that at least three meters did not meet specifications. The Corps of Engineers subsequently relaxed the current specification (to ±10% of full scale and ±5°) in order to expedite the start of the field program.

From the beginning, a persistent problem in the cassette recorder/reader system produced random interrupts in the data blocks, thus making time sequencing of data ambiguous. InterOcean could not fix this problem, which persisted throughout the program and greatly complicated data quality screening. Retrofits of clocks to produce time marks on the cassette tapes were of only partial help. These clocks proved to be only good enough to serve as an additional qualitative tool to an essentially manual time-sequencing check procedure.

Installation of all six stations was finally accomplished during the period 8-14 February 1979. Initial assignment of instruments to each station is shown in Table 2.

Table 2. Initial Station/Meter Assignments

Station	Position	Meter Serial #	I.D. (mV)	Hi Tide Water Depth (m)	Depth (cm from bot.)	V_x mV/cm/sec	V_y mV/cm/sec	Station Initiation Time: Time (GMT)*	Station Initiation Time: Julian Day	Station Initiation Time: Year
1 San Pablo	1 To 2 Miu 3 Bot	6271017 6271013 6271019	600 800 900	10.1- 10.7	820 520 90	1.53 1.61 1.53	1.45 1.53 1.58	2030	39	1979
2 Carquinez	1 Top 2 Mid 3 Bot	6271011 6271010 6271007	200 1400 1000	9.75- 10.1	760 450 90	1.57 1.50 1.64	1.72 1.53 1.60	0130	46	1979
3 Benicia	1 Top 2 Mid 3 Bot	6271002 6271001 6271014	1500 500 400	10.1- 10.7	820 520 90	1.66 1.67 1.50	1.62 1.59 1.69	2130	40	1979
4 Port Chicago	1 Top 2 Mid 3 Bot	6271004 6271008 6271018	700 100 1200	9.75- 10.1	760 460 91	1.57 1.62 1.56	1.60 1.57 1.61	2200	45	1979
5 Chipps Island	1 Top 2 Mid 3 Bot	6271012 6271006 6271020	1700 300 1600	7.6- 7.9	520 400 90	1.75 1.74 1.84	1.66 1.66 1.58	2100	45	1979
6 Griz. Bay	2 Mid (at MLLW)	6271016	1300	3.0	120	No current sensor		0100	41	1979

*GMT - Greenwich Mean Time

It was attempted throughout the study to hold these assignments constant, but numerous instrument failures resulted in unavoidable departures from this scheme. Complete documentation of instrument changes for each station is contained in Appendix 3.

The pattern of instrument failure and malfunction evidenced prior to installation continued after deployment in the field. In addition, several ship collisions with the pilings used for moorings and one case of surface recorder vandalism caused some additional loss of data. Overall data recovery was about 67 percent.

An extraordinary amount of field maintenance of the equipment was required. Failures occurred in sensors, cables and equipment such as:

a) Leaks of hydraulic fluid out of pressure (tide) sensors of nearly all such equipped probes due to loose tubing connections,

b) Component failures in recorders causing large loss of data,

c) Failure due to shorts causing battery drainage and subsequent data loss,

d) Repeated cable failures (turbidity sensors),

e) Variable sensor failures,

f) Defective current probe fastenings causing flooding of three meters, replacement of all current probes, and recalibration of all meters,

g) Continual quality problems in data recording and reading systems.

KLI personnel were able to carry out certain repairs, either in the field or at the laboratory. Most instrument problems not fixed by replacing circuit boards, tightening connectors, replacing cables, or repairing broken wires, however, were restricted to warranty repair by InterOcean. While adequate service was generally received when units were sent to the factory in San Diego, time delays were unavoidable and occasional failure to fix the problem of course hindered the flow of field operations and data return.

Field operations also were impeded by weather and sea conditions. High winds and heavy chop were not uncommon and presented challenges to personnel attempting to service the stations. With experience, however, procedures evolved to

make the task more manageable. Corrosion of both mooring and instrument cables was another problem. This corrosion was alleviated somewhat by heavy zincing, but replacement of cables and parts was at times still necessary.

Still other sources of problems were collision or vandalism. While infrequent in occurrence (especially considering the high potential for such incidents), the events were sometimes quite serious. Two instances of sensor damage due to subsurface collision with some object occurred, one at station 2 (Carquinez) and one at station 5 (Chipps Island). Two stations were hit, apparently by ships. Station 3 (Benicia) suffered damage to the batteries and recorder from one collision. Station 4 (Port Chicago) was hit twice, with resultant standoff damage and, in one instance, recorder and battery damage as well. One instance of apparent vandalism occurred at station 1 (San Pablo). As documented in detail in correspondence between KLI, the Corps of Engineers, and the U.S. Coast Guard (Appendix 5), irreparable damage was caused to much of the equipment, fortunately limited to that above the surface. This was the most serious instance of damage from outside interference, both in terms of cost and data loss. The station remained out of operation for two months. Severe restrictions and data loss were caused after that period as well, since the recorder used for that station after the incident was the spare. The Corps did not choose to purchase a replacement for the station. It was their decision to use the equipment from station 1 as spares to keep the other stations operational at the expense of station 1. During the program, no moorings or major instrumentation was lost due to natural causes.

In early summer 1979, it became apparent that fouling by marine organisms such as hydroids, barnacles, and isopods would present major interference to accurate data measurement of certain parameters (especially turbidity) by the meters. The decision was made to periodically clean the meters as part of monthly servicing; in practice this was quite time-consuming and difficult to accomplish. These monthly cleanings were also found to be inadequate, but budgetary restrictions prevented more frequent cleanings.

When all the meters were removed for general overhaul, cleaning, and recalibration in October 1979, the fouling of the spring and summer season was painfully evident (Figure 7 and Table 3). Over two weeks had to be spent in the complete scraping, sanding, and cleaning of all subsurface equipment. In an effort to decrease the chances of further fouling, antifouling paint was applied to all meters, even though the pressure cases were copper-nickel.

Figure 7. Fouled Meters After One Month Underwater During Fouling Season

Table 3. Listing of Fouling Conditions of Moored Equipment Removed 2-3 October 1979

Meter Number	Probe Turbidity	Thermistor	Current	Salinity	Depth
6271010	1*	1	1	1	1
6271018	1	1	1	1	1
6271012	2	2	2	2	-
6271020	3	3	3	3	2.8
6271015	2	1.8	2.5	1.5	3
6271019	1	1	1	1	1
6271013	1	1	1	1	1
6271008	3	1	1	1	1
6271017	2.5	1	1	1	1
6271007	3	1	1	1	1
6271011	1	1	1	1	1
6271016	1	1	1	1	1
6271002	1	1	damaged	1	-

*Fouling condition rated within the continuum:

1 = fouled; 2 = moderately fouled; 3 = not fouled

The recalibration of instruments took approximately two weeks. Details are discussed in the next section. Re-establishment of stations was done in early November with attention paid to original instrument/station assignments.

Instrument problems continued to occur after this period and increased somewhat in frequency as time went on. By the end of the data acquisition period, all field equipment was badly in need of servicing and, in some cases, replacement. These failures are documented in Appendix 3.

CALIBRATION STUDIES

Several procedures for calibrating instruments and checking data accuracy were utilized throughout the study. Prior to installation and mid-way through the data acquisition period, laboratory calibration tests were performed on all the instruments. A special study to evaluate depth sensor performance was done, utilizing data collected under both field and controlled conditions. In addition, ground truth data for conductivity, temperature, and salinity, regularly collected at each servicing, were utilized in evaluating instrument performance.

Laboratory Instrument Calibration

At the onset of the project, all probes were calibrated by InterOcean Systems Inc. prior to shipment. These tests included temperature-conductivity calibrations in the InterOcean STD calibration bath facilities, turbidity calibrations with distilled water, and tow tank calibrations of the electromagnetic current sensors at the Scripps Institution of Oceanography facilities. Results of these calibration tests are given in Appendix 11. Subsequent values used in the data processing to convert the millivolt outputs recorded on the cassette tapes to reported values of temperature, salinity, current, etc. are given in Table 4.

Upon receipt of the instrumentation at KLI, tests of the complete systems to be moored were made (i.e., three meters, cables, recorders, batteries, etc.). A number of electronic failures occurred and were remedied. Those factors affecting calibrations were the following:

a) Fifteen of seventeen turbidity sensors were out of calibration and were recalibrated to original specifications with distilled water.

b) The V_x and V_y (cross current speed components) were reversed in orientation to a fixed mark compared to specifications on all meters except one. This odd meter was changed to be consistent with the others. Scripps tow tank calibration data were still valid.

c) Three of the sixteen current probes did not meet specifications (±0.05 m/sec) due to noisy calibration data. The Corps of Engineers subsequently relaxed this specification to "±10% of full scale" in order to avoid delays in deployment.

Table 4. Calibration Conversion Factors from Millivolts to Oceanographic Parameter

A. Currents

Meter #	I. D. Voltage	Original Sensors (Jan-Sep 1979) V_x $\frac{mV}{cm/sec}$	V_y $\frac{mV}{cm/sec}$	New Sensors (October 1979--) V_x $\frac{mV}{cm/sec}$	V_y $\frac{mV}{cm/sec}$
6271001	0.5V	16.7	15.9	14.2	14.1
6271002	1.5V	16.6	16.2	14.4	14.1
6271004*	0.7V	15.7	16.0	14.7	14.6
6271006	0.3V	17.4	16.6	14.3	14.3
6271007	1.0V	16.4	16.0	14.3	14.3
6271008	0.1V	16.2	15.7	23.4	23.2
6271010	1.4V	15.0	15.3	14.1	14.1
6271011	0.2V	15.7	17.2	14.3	14.3
6271012**	1.7V	17.5	16.6	14.3	14.3
6271013	0.8V	16.1	15.3	14.3	14.2
6271014	0.4V	15.0	16.9	14.3	14.3
6271015	1.1V	15.6	15.0	13.8	14.1
6271016	1.3V	NO CURRENT SENSOR		NO CURRENT SENSOR	
6271017	0.6V	15.3	14.5	15.0	15.3
6271018	1.2V	15.6	16.1	15.0	15.3
6271019	0.9V	15.3	15.8	13.6	14.3
6271020***	1.6V	18.4	15.8	24.7	24.3

* New current sensor installed in August, 1979
** New current sensor installed in July, 1979
*** New current sensor installed in August, 1979

Table 4 (continued)

B. Temperature (°C) = 0.01 x millivolts

C. Depth (ft) = 0.01 x millivolts****

D. Conductivity (mmhos/cm) = 0.01 x millivolts

E. Transparency (% transmittance) = 0.1 x millivolts

****See Table 6 for additional corrections to MLLW reference.

d) Tide (depth) probes were checked for functionality but not re-tested at depth (20-30 feet).

Upon installation of equipment in the field on 8-14 February 1978, ground truth data were gathered in the field as described in the section below. Special measurements and studies associated with tide measurements are also discussed separately below. When equipment components failed and were pulled from the moorings, the pertinent probes were repaired and brought back to specifications by InterOcean before installation. However, since only one recorder, one bottom meter, and two upper meters were available as spares, and since component failures were frequent in the field, complete recalibration of equipment was possible only upon pulling all moorings from the field with subsequent loss of data. Such a refurbishment and recalibration of all instruments was done in the period from 2 October to 2 November 1979. Recorder clocks were installed at this time also (Appendix 9). Because several of the electromagnetic current sensors had defective welds which had failed and caused flooding of the electronics, the manufacturer replaced all of the other current sensors at this time as well to prevent possible future flooding of other probes.

Upon removal from the water, the meters were very heavily fouled with marine organisms. Before calibration tests could be carried out, the equipment had to be cleaned, a process which took a full two week's effort by three or four people. Once this was accomplished, each of the probe parameters was calibrated according to the procedures described in the equipment manuals supplied by InterOcean with current calibration checks done by tows performed at Scripps Institute of Oceanography. Meters which were known to have problems or found defective during testing procedures were repaired by KLI personnel or sent to InterOcean for repair, depending on the complexity of the problem.

Evaluation of current sensor performance outside of special test facilities is extremely difficult. The digital data scanner reads V_x, V_y, direction and thus indicates functionality of the probe and general level of the current. However, calibration under field conditions was difficult because the actual current flow speed and direction values below the surface are unknown. For these reasons it was decided to again tow the meters in the tow tank facility at Scripps Institution of Oceanography.

Scripps was chosen since it was known that electromagnetic contamination that interfered with the electromagnetic field of the current sensor was not too severe at this site, and the original calibrations were accomplished there.

During the towing operations five meters were discovered which would not give stable outputs from the current sensors at a steady speed. The value of the output was approximately correct, but unacceptable "noise" levels of ±20-25% were noticed. These meters were returned to InterOcean for repair as it was instrument malfunction rather than calibration noise causing the problems. Another trip was then made to Scripps to retow these meters. Four checked out fine but problems remained with one (number 20) which was again returned to InterOcean for repair. Several small electronic problems were detected and allegedly repaired. However, the current sensor was still found to be noisy during testing after its return to KLI in Santa Cruz. Since further delays in data collection were felt to be intolerable, this meter was not returned to InterOcean for a third repair attempt. Instead, it was "calibrated" by comparing output values with two other meters (that had been calibrated at Scripps) in a revolving flow field. The output from the two control meters in the revolving flow field agreed very closely with each other and showed that this flow was very stable over time and reproducible. After calibration, meter number 20 was reinstalled with the other meters with the plan to change it with the spare meter as soon as it was repaired and returned from InterOcean (a routine repair for a faulty turbidity sensor).

Table 4 shows the resulting calibration factors for the current sensors, both the original probes and the replacement probes. According to Marsh McBirney, Inc. (MMI), the sensor and electronic package are designed to give a reading of 2 ft/sec per volt which translates to 16.4 mV per cm/sec. The results listed in Table 4 show that the values obtained from the tow tank for both the old and new heads are close to that expected. With the exception of meters 8 and 20, the differences noted are not unusual, according to MMI, for instruments with randomly matched sensors and electronic packages. The differences noted with numbers 8 and 20 are unexplainable. Several attempts were made to rectify this problem, but these two meters were found to remain widely variant from the other meters. Since the data produced by each meter were processed using calibration values unique to that meter, the calibrations were utilized even though they were different from the rest. No unexpected differences were noted in meter-to-meter comparison of currents (at the same station), so it is felt that the calibration values for these two meters did not drift with time. Also, changes noted in going from the old to new sensor heads using the same electronics package are not unusual. The fact that these values are all relatively close to the theoretical value lends confidence to those calibration values.

During discussions with Marsh McBirney while the meters were out of the water, it was learned that they had received similar results at Scripps tow facility, i.e., noisy meters.

Since the fault was with noise and not with output level, however, the calibrations reported are not felt to be wrong, just uncertain. MMI has found that the tow facility at the David Taylor Model Basin in Carder Rock, MD is free from interference with their sensors. However, the improvement relative to our fast tidal flow application was not felt to warrant the increased delay.

The instruments were reinstalled in the field on 2 November 1979, with the exception of Grizzly Bay which was reinstalled 6 November 1979.

Ground Truth Data Checks

As described in the section on servicing procedures in this report, ground truth data for current speed and direction, temperature, and salinity were collected regularly. In addition, the digital data readout was utilized in the field to test actual probe readings at the same time.

To provide a means for integrating formal ground truth and instrument checkout procedures, conductivity and temperature data from the deck readout were converted to salinity values using the algorithm contained in the normal data processing software (Appendix 8). These data, along with field salinity and temperature data, were summarized for each month of data. These summaries are included as the fourth section of Appendix 12 of this report. Overall agreement between calculated probe readouts and field salinities was very good, and the summaries provide a tool for use in future data acquisition systems design. Alone the summaries comprise a body of useful oceanographic data from the sampling station locations.

After February 1980, measures of water depth were taken in the field as part of the ground truth procedures during each field visit. These and other related measurements are discussed below.

Tide (Pressure Sensor) Calibration Problems

Of all of the equipment problems encountered during the project, such as frequent component failures, tape reading errors, and the like, those problems encountered with the depth (pressure) sensors were least satisfactorily resolved. As a result, confidence is low in the absolute reference to mean lower low water (MLLW) for the tide data. Because a lot of effort was put into manually checking time sequencing problems (caused by operational and cassette recorder interrupts), the absolute sequencing in time of these data is felt to be accurate. Thus, amplitude data and correlations of such data as currents or salinities with tides can be used, even though the reference to MLLW is unsure.

Because only one spare meter with a depth sensor was available and this meter was constantly needed to keep stations in operation, priority was placed upon keeping in operation without causing large data gaps in all parameters. Efforts to calibrate the pressure sensors are delineated below.

First of all, the mooring was designed so that each meter could be moored, pulled for cleaning or maintenance, and then returned to the exact spot and depth as before. Thus the same reference elevation for the pressure sensor was maintained for each month. This was accomplished by installing the meters on a pulley system of cables which were attached to existing pilings near the edge of channels. These mooring systems are shown in Figure 5. The top pulley was supported by a stand-off arm clamped high on the piling. The bottom pulley was shackled to a heavy anchor placed on the bottom and the wire was tensioned between the pulleys. Each time, the meters were placed at the same position on the marked wire and a stainless steel turnbuckle served as a wirestop on the bottom pulley, thus assuring reproductible positioning of meters, including the bottom meter equipped with the pressure sensor.

Secondly, each piling was surveyed by a civil engineering surveying firm (Towill, Inc.) and an elevation mark was placed upon each piling referenced to MLLW, accurate to ±0.3 cm at each station except for station 1, San Pablo, which was accurate to ±3 cm. Monument records for these surveys are included in Appendix 6. Then careful measurements were made in the field of the wire lengths of the mooring system in order to calculate the depth of each probe relative to the Towill survey mark on the piling. These measurements were also verified for each station by divers using a tape measure. The relationships between variously measured heights at a station are shown schematically in Figure 8. Resulting elevations for each meter and for each station are shown in Figure 9.

Pressure sensors were initially calibrated by InterOcean at their test facilities (Appendix 11). In addition both the zero and the span (0-5 volts corresponding to 0-50 feet) could be checked and adjusted electrically, the latter by use of a standard resistor shunt provided for each instrument across two arms of the wheatstone bridge circuit.

Inconsistencies in field water level measurements and sensor output, plus the necessity to adjust spans (5 to 23 percent of range) led to low confidence in stability of the pressure probes in the field moorings. Special tests for response and calibration were done in a still, deep reservoir in the Santa Cruz mountains. These tests, described in Appendix 7, involved suspending the probes on a carefully-measured, weighted line. When lowered from the surface to about a 30 foot depth, the response times for all the

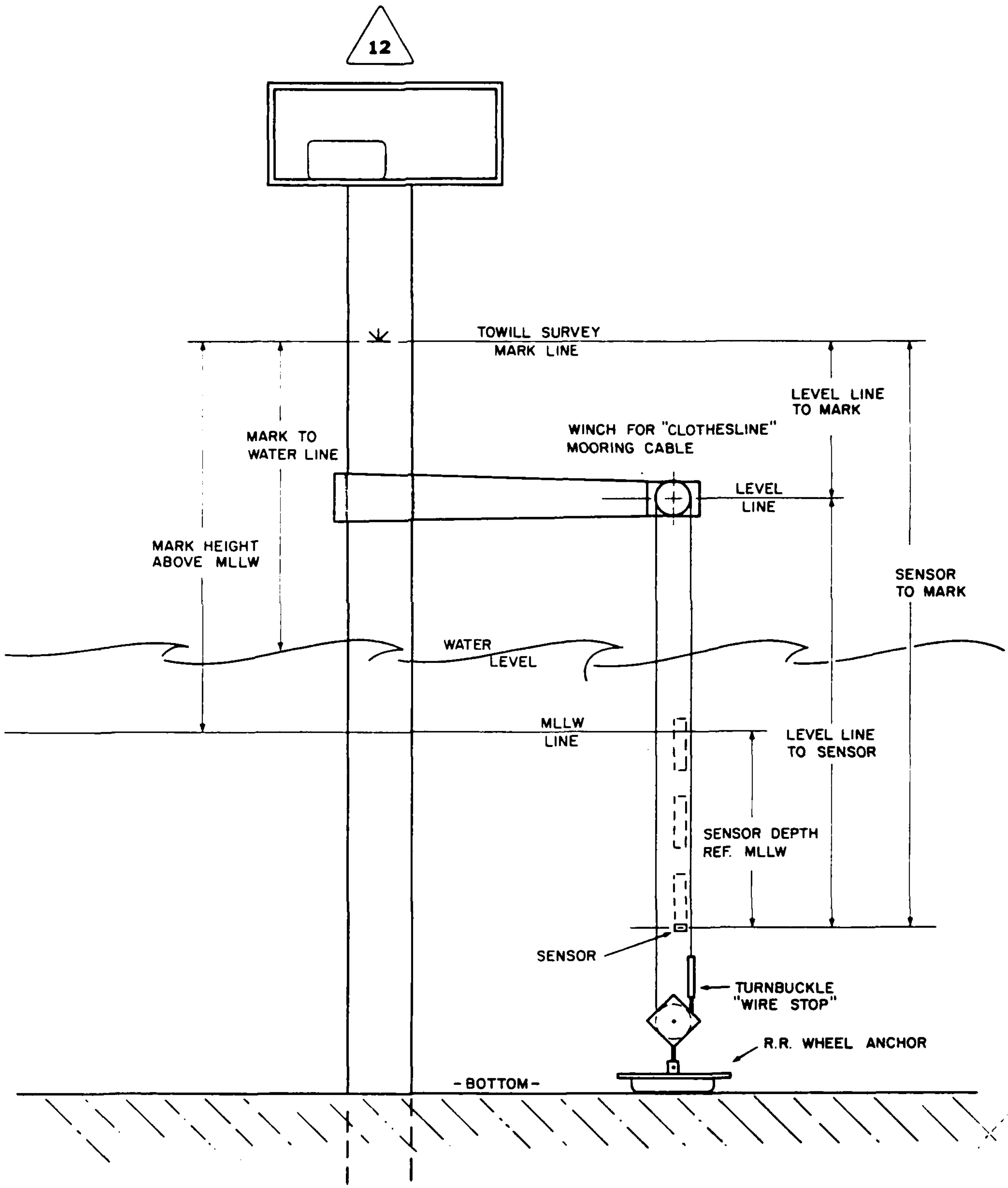


Figure 8. Sensor Depth Calculations

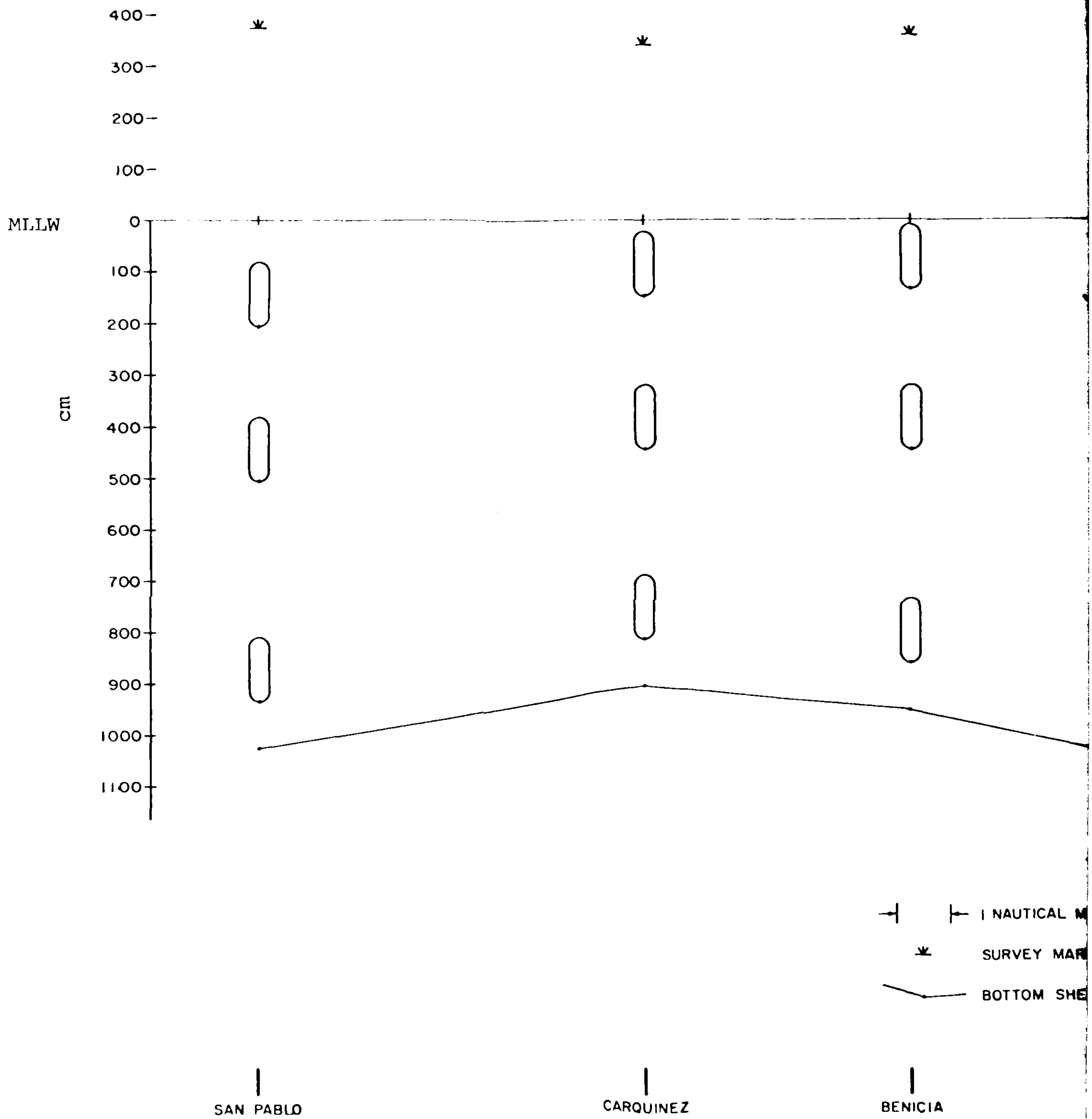
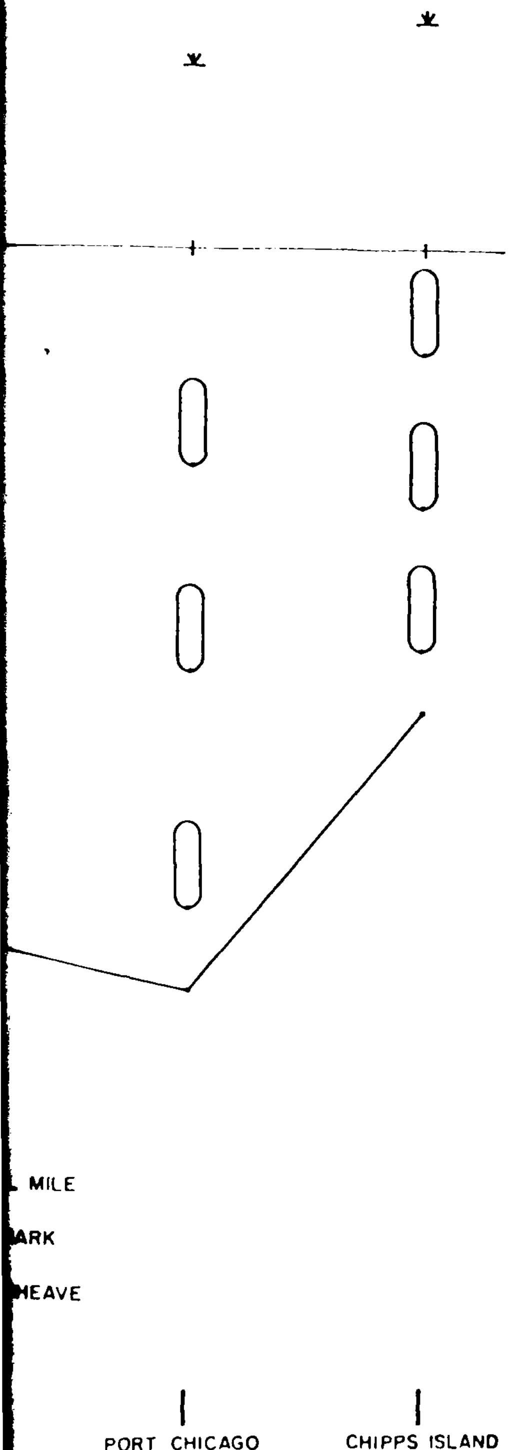


Figure 9. Probe Positions and Towill Survey Mark Posit



tions

pressure sensors to reach an acceptable asymptotic value were measured in hours. These long response times, found on all probes, were inherent in the equipment design and perhaps were related to temperature equilibration of the instrument package. The manufacturer's stated time constant of the pressure (tide) sensor was 200 seconds. When equilibrated at about 25 feet depth for a long time, then dropped to 30 feet, the response time was acceptably short, in the range of minutes (Appendix 7). Again, however, the absolute depth readings of these pressure sensors as removed from the field had drifted significantly from the true depths. Best values for the depth error for each probe are given in Table 5.

For data processing purposes, the Towill survey data and sensor depth measurements were combined with these depth corrections for each probe in order to reference the tidal data recorded to MLLW. Because of the large drift errors in the pressure sensor, found both with the discrete lake calibrations and by examination of ground truth water-level measurements during station visits, efforts were not made to add an additional correction to these nominal tide values due to water column densities (salinity and temperature). These nominal values used are thus given in Table 6. In light of the pressure sensor drift between calibrations, however, these reference level corrections are undoubtedly subject to error.

Table 5. Summary of Depth Sensor Corrections from Tests in Deep Reservoir

Sensor Number	30 ft Value (0-30 ft)	30 ft Value (25-30 ft)	Best 30 ft Value (ft)	Correction (ft)	Correction (cm)
15	29.68	29.59	29.6	0.4	12
14	27.41	27.47	27.4	2.6	79
7	27.03	26.97	27.0	3.0	91
18	29.97	30.06	30.0	0.0	0
19	28.68	28.78	28.7	1.3	40
20	28.27	28.35	28.3	1.7	52

Table 6. Nominal Correction Values Used in Data Processing to Reference Tidal Data to MLLW

Month	Tape Number	Pressure Sensor Correction (cm)				
		San Pablo	Carquinez	Benicia	Port Chicago	Chipps Is.
2	0645	-928	-925	-786	-971	[illegible]44
3	5301	-928	-925	-786	-919	-544
4	5332	-928	-925	-786	-919	-544
5	5347	-928	-925	-786	-919	-544
6	5350	-928	-925	-786	-919	-544
7	5352	-928	-925	-786	-919	-584
8	5354	-928	-925	-786	-931	-584
11	5376	-928	-725	-786	-899	-584
12	5380	-928	-725	-786	-911	-584
13	5410	-928	-725	-786	-911	-584
14	5441	--	-725	-786	-899	-584
15	5467	--	-725	-786	-899	-584
16	5471	-928	-725	-786	-899	-584
17	5490	--	-725	-786	-939	-584
18	5511	-888	-725	-786	-939	-584

DATA PROCESSING

Description

Data processing for the project involved inputting the data collected on cassette tape into the computing system, standardizing and documenting the data, and variously reducing it per government specifications.

Specifications for Data Processing and Format

Original specifications set forth in Schedule "A" (Scope of Services, Appendix 1) in the contract called for the following data reductions:

For the five detailed in-situ stations:

A. Tidal elevation

1) For each station, plot filtered data versus time.

2) For HH, LH, HL, and LL, plot elevations versus time versus distance.

3) For HH, LH, HL, and LL, plot time lag versus time versus distance.

B. Currents

1) For each station and each depth plot data versus time.

2) For each station and slack, maximum ebb and maximum flood, plot vertical lag time versus time.

3) For each depth and slack, maximum ebb and maximum flood, plot lag time between stations versus time.

C. Salinity

1) For each station and each depth, plot data versus time.

2) For each depth, plot salinity versus distance versus time.

3) For each station, plot salinity versus depth versus time.

D. Temperature

1) For each station and each depth, plot data versus time.

2) For each depth, plot temperature versus distance versus time.

3) For each station, plot temperature versus depth versus time.

E. Turbidity

1) For each station and each depth, plot data versus time.

2) For each depth, plot turbidity versus distance versus time.

3) For each station, plot turbidity versus depth versus time.

4) Plot turbidity versus salinity.

For the limited in-situ station:

A. Salinity - plot data versus time.

B. Temperature - plot data versus time.

C. Turbidity - plot data versus time.

After data processing had begun, it became apparent that a modification in display methods would be more workable than the original. In January 1980, the following change in specifications for current data was authorized (Contract Modification, Appendix 4):

B. Currents

1) For each station and each depth plot speed and true direction versus time.

2) For each station and each depth plot mainstream and transverse components of speed versus time.

3) For each station plot speed for all depths versus time.

4) For each depth plot speed for all stations versus time.

For the purpose of data reduction, a government computing system (Lawrence Berkeley Laboratory) was made available. The raw and reduced data for each month and 20 copies of the specified plots in microfiche form were to be delivered to the government within fifteen days after the end of each month. The format for the raw data was specified as follows:

a) 9-track, 800 bpi tape, ASCII.

b) Tape shall be blocked twelve 80-character records per block, even parity.

c) The first tape record will be a header containing the following information: an identifying label of 1 to 10 characters; date and time (Greenwich Mean Time, GMT) of first sampling on the tape; date and time (GMT) of the last sampling; number of tapes in month's submittal, sequence number of reel if a multi-reel submittal, and the number of records on the reel.

d) Each record will represent one data sampling and will contain at least a station ID, date and time (GMT) of sampling, current magnitude in cm/sec, current direction, salinity to tenths in parts per thousand, temperature, turbidity, and tidal stage in centimeters.

e) One month of data per tape.

The maximum data gap was not to exceed one month for any one station. Total down time during the period of observation was not to exceed 30 days per year. Due to a large number of equipment failures, however, these specifications were not met.

Software Development

The basic software necessary to go from cassette to finished data plots was completed prior to the final installation of the equipment. No <u>real</u> data had been fed through the system, however, so final testing was delayed until the first data tapes arrived from the field.

The initial scheme for file management and graphics production was as outlined below:

A. Initial Procedure to Screen and Process Cassette Data

1) Field Books: Field notes (log, Data Logger Check Sheets, Ground Truth Data Sheets, Data Interrupt Sheets--see section on servicing

procedures for each station shall be kept to document field operations.

2) Preliminary Data Screening and Processing, Write Raw Data and Reduced Data Tape Files: Data will be moved from cassettes to organized 9-track (9-T) data tapes by interactive processing methods in several steps.

   a. Cassette files will be moved onto 9-T files and printed. Visually scan print for bad data.

   b. 9-T files will be loaded onto disk files.

   c. Using field notes and TEXT EDITOR programs procedures delete appropriate starting and ending records; write file header records; count records; write raw data tape files.

   d. Execute major screening and processing program. Screen for bad characters and extreme values; rotate axes, transform data, (vector) average; generate time code; count and write output records. Print tape records; check against field book.

   e. Assemble 'Reduced Data Tape' with specified file and record headers.

3) Anticipated Change in 'Basic Data Tape' Creation Procedures:

   a. Hardwire cassette reader into system so as to consolidate steps A.2.a and A.2.b. Write disc files directly.

   b. Move entire system to Lawrence Berkeley Laboratory (LBL) following evaluation of hardwiring cassette reader and evaluation of LBL system's ability to accept reader into interactive system.

B. Initial Procedure to Develop Graphics

1) Computational and Analytical Stages: Project graphics will be developed in a two stage process. Environmental parameters from each 'Reduced Data Tape' record will be plotted against time. Each plot will be visually interpreted for critical values. These critical values will be recorded and entered as data files for additional graphics presentation.

a. Each file of 'Basic Data Tape' will be displayed such that each parameter is plotted against time. Each parameter will be plotted alone against time at several stations (Data vs. Time vs. Distance). This is a batch process with hard copy plot output.

b. Plots of B.1.a. (above) will be interpreted and critical values estimated (e.g., time of higher high tides) and then recorded on punched cards for later graphics processing B.1.c. (below).

c. Specialized plots of various parameter critical values against time and distance will be prepared as a batch process with hard copy output.

2. Anticipated Modifications: It is very probable that step B.1.b. can be automated by use of interactive graphics techniques. Plot CRT images could be scanned for critical points. Critical points could be recorded by light pencil techniques. Feasibility of this stage can be judged more knowledgeably following experience with hard copy plots.

The basic unit of the processing scheme outlined above was to be a cassette tape representing one month of data (6 cassettes per month). Early in the project it was decided to alter the basic scheme by collecting cassettes every two weeks (12 cassettes per month) for fear of not discovering instrument problems missed by merely checking each sensor. This move increased our paperwork since accurate records had to be kept on each cassette removal and installation. More time was also required to merge the two component files into a monthly "Raw Data Tape" file.

When real data began arriving from the field, it became apparent that processing of the data cassettes would be vastly more complicated than originally anticipated. Numerous shifts, jams, and garbage characters occurred frequently in the data due to problems in the tape writing and reading systems still unresolved by the equipment supplier even after repeated attempts to generate action. Figures 10a through 13b illustrate the nature of some of these data recording problems. These problems were fundamentally very serious in that ambiguities in data-time sequencing were introduced and a great deal of computational and manual data screening was necessary in order to ensure that the data were properly placed in time. The many other hardware problems experienced in the field (Appendix 3) created substantial data problems of their own. For example, when

Figure 10a. Cassette Data Record, Normal Operation

```
 1            8            ce0103.b
99999999999999999999999999999999999999999999999999999999999999999999999999999999
99999999999999999999999999999999999999999999999999999999999999999999999999999999
99999999999999999999999999999999999999999999999999999999999999999999999999999999
99999999999999999999999999999999999999999999999999999999999999999999999999999999
 2            0            ce0103.b
 2650 2449 1278-0000 2651 2445 1278-0000 2652 2446 1278-0000 2653 2444 1278-0000
 1079-0194-0582 1922 1079-0380-0727 1864 1079-0382-0662 1864 1079-0355-0621 1909
-0592 2248 1257 2368-0592 2211 1257 2405-0592 2239 1258 2403-0592 2236 1257 2395
 0588-1005 0091 2373 0588-1103-0052 2349 0589-1114-0072 2303 0589-1072-0116 2317
 3            0            ce0103.b
-0802 2471 1244 1928-0802 2465 1244 1930-0802 2492 1244 1843-0802 2467 1244 1995
 0807-0990-0150 2414 0807-1113-0173 2394 0807-1036-0119 2375 0807-1072-0234 2359
 2757 2499 1276-0000 2757 2500 1276-0000 2757 2501 1276-0000 2757 2501 1276-0000
 1079-0506-0246 2215 1079-0558-0332 2197 1079-0534-0356 2190 1079-0574-0379 2179
 4            0            ce0103.b
-0592 2243 1256 2401-0592 2243 1256 2412-0592 2244 1256 2424-0592 2243 1256 2433
 0588-1192-0386 2319 0589-1186-0455 2291 0589-1139-0588 2292 0589-1215-0475 2292
-0802 2487 1244 1603-0802 2475 1244 1639-0802 2487 1244 1604-0802 2506 1243 1636
 0807-0665-0168 2303 0807-0748-0221 2303 0808-0689-0368 2267 0807-0616-041[illegible] 2269
 5            0            ce0103.b
 2803 2531 1275-0000 2803 2531 1274-0000 2803 2531 1275-0000 2803 2530 1275-0000
 1079-0341-0238 2133 1079-0492-0222 2147 1079-0460-0273 2133 1079-0461-0272 2119
-0593 2358 1253 2245-0593 2334 1253 2248-0592 2315 1253 2256-0592 2308 1254 2256
 0589-0907-0305 2348 0589-0975-0384 2364 0589-0955-0395 2348 0589-0962-0354 2348
 6            0            ce0103.b
-0802 2579 1239 1662-0802 2581 1239 1677-0802 2580 1239 1639-0802 2578 1239 1631
 0807-0567-0258 2339 0807-0655-0286 2348 0808-0824-0159 2347 0807-0824-0165 2361
 2833 2586 1272-0000 2832 2586 1272-0000 2832 2586 1272-0000 2832 2587 1272-0000
 1079-0486-0197 2221 1079-0629-0230 2201 1079-0585-0296 2160 1079-0552-0333 2119
```

Note: Cassette data records as written by BASIC program readc.bas on UNIX system file where system is performing adequately. The first cassette block (data from the top and middle sensor packages) is lost due to data interrupts in reading the first block, and it is unclear at what point the file should actually start.

Figure 10b. Finished Raw Data Record, Normal Operation

```
-0592 2249 1257 2368-0592 2211 1257 2405-0592 2239 1258 2403-0592 2236 1257 2395
 0588-1005 0091 2373 0588-1103-0052 2349 0589-1114-0072 2303 0589-1072-0116 2317
-0802 2471 1244 1928-0802 2465 1244 1930-0802 2492 1244 1843-0802 2467 1244 1995
 0807-0990-0150 2414 0807-1113-0173 2394 0807-1036-0119 2375 0807-1072-0234 2359
 2757 2499 1276-0000 2757 2500 1276-0000 2757 2501 1276-0000 2757 2501 1276-0000
 1079-0506-0246 2215 1079-0558-0332 2197 1079-0534-0356 2190 1079-0574-0379 2179
-0592 2243 1256 2401-0592 2243 1256 2412-0592 2244 1256 2424-0592 2243 1256 2433
 0588-1192-0386 2319 0589-1166-0455 2291 0589-1139-0588 2292 0589-1215-0475 2292
-0802 2487 1244 1603-0802 2475 1244 1639-0802 2487 1244 1604-0802 2506 1243 1636
 0807-0665-0168 2303 0807-0748-0221 2303 0808-0689-0368 2267 0807-0616-0413 2269
 2803 2531 1275-0000 2803 2531 1274-0000 2803 2531 1275-0000 2803 2530 1275-0000
 1079-0341-0238 2133 1079-0492-0222 2147 1079-0460-0273 2133 1079-0461-0272 2119
-0593 2358 1253 2245-0593 2334 1253 2248-0592 2315 1253 2256-0592 2308 1254 2256
 0589-0907-0305 2348 0589-0975-0384 2364 0589-0955-0395 2348 0589-0962-0354 2348
-0802 2579 1239 1662-0802 2581 1239 1677-0802 2580 1239 1639-0802 2578 1239 1631
 0807-0567-0258 2339 0807-0655-0266 2348 0808-0824-0159 2347 0807-0824-0165 2361
 2833 2586 1272-0000 2832 2586 1272-0000 2832 2586 1272-0000 2832 2587 1272-0000
 1079-0486-0197 2221 1079-0629-0230 2201 1079-0585-0296 2160 1079-0552-0333 2119
-0592 2432 1249 2218-0592 2421 1249 2218-0592 2400 1250 2223-0592 2385 1252 2220
 0589-1021-0359 2331 0589-1165-0358 2332 0589-1244-0255 2361 0589-1329-0104 2361
-0802 2582 1239 1564-0802 2586 1239 1568-0802 2588 1239 1547-0802 2582 1239 1619
 0807-0559-0329 2305 0808-0667-0309 2346 0807-1156 0150 2371 0807-0719-0198 2346
 2851 2594 1272-0000 2851 2596 1272-0000 2851 2595 1272-0000 2851 2595 1272-0000
 1079-0398-0279 2203 1079-0532-0286 2233 1079-0510-0230 2247 1079-0522-0176 2233
-0593 2096 1265 2179-0592 2096 1265 2176-0592 2092 1265 2177-0592 2091 1265 2178
 0589-0943-0167 2317 0589-1016-0200 2318 0589-1050-0153 2318 0589-1056-0219 2317
```

Note: Finished raw data records after interactive data processing completed. Based on expected amount of data for time period involved and comparisons of tide data from first records of this file with that of tide data from last records of previous file, starting point and starting time for data were determined.

Figure 11a. Cassette Data Record, Shifted Data

```
14          0          ce0103.ax
0499 2896 0890-0529 0574 2881 0890-0531 2871-0592 1532 1117 0301-0592 1528 1117
0313-0592 1499 1117 0335-0592 1517 1117 0329 0589-0980 1436 3103 0589-1056 1538
3109 0589-0962 1561 3094 0589-1002 1637 3153-0802 1622 1117 0698-0802 1614 1117
0767-0802 1606 1116 0761-0802 1607 1117 0756 0807-0687 1131 2992 0808-0739 1209
15          0          ce0103.ax
3037 0809-0790 1069 3008 0807-0787 1096 2993 1654 1705 1070 0136 1654 1684 1070
0126 1654 1687 1070 0124 1654 1689 1070 0122 0890-0276 0317 2949 0890-0350 0308
2926 0890-0337 0377 2938 0890-0348 0372 2945-0592 1527 1115 0361-0592 1526 1115
0371-0592 1532 1115 0374-0592 1551 1116 0369 0589-1067 1416 3052 0589-1110 1502
16          2          ce0103.ax
3067 0588-1128 1515 3095 0589-1162 1596 3095-0802 1598 1117 0813-0802 1612 1117
0715-0803 1626 1117 0691-0802 1622 1117 0679 0807-0767 1079 2988 0808-0795 1052
2998 0807-0942 1280 3007 0807-0848 1169 3006 99999 1704 1071 0104 1655 1701 1071
0124 1655 1695 1071 0111 1655 1704 1071 0111 0890-0306 0398 2911 0890-0445 0456
17          0          ce0103.ax
2911 0891-0446 0375 2926 0890-0523 0406 2938-0592 1574 1117 0356-0592 1579 1117
0363-0592 1585 1117 0353-0592 1586 1117 0353 0589-0787 0395 2896 0589-0931 0428
2850 0589-0895 0472 2882 0589-0892 0468 2869-0802 1643 1118 0702-0802 1644 1118
0693-0802 1641 1118 0714-0802 1640 1118 0729 0807-0642 0216 2722 0809-0816 0220
18          0          ce0103.ax
2794 0807-0690 0104 2808 0807-0901 0000 2794 1647 1785 1072 0169 1646 1783 1072
0179 1647 1787 1072 0167 1647 1783 1072 0165 0890-0125 0241 2769 0890-0174 0304
2762 0890-0173 0303 2762 0890-0180 0277 2763-0592 1589 1115 0399-0592 1588 1115
0395-0592 1588 1115 0395-0592 1590 1115 0403 0589-0716 0307 2753 0589-0908 0045
```

Note: Cassette data records as written by BASIC program readc.bas on UNIX system file. Header records, which signal beginning of data block, indicate block number, error code and file name. Error code 0 signifies normal data block; error code 1 (not shown) signifies cassette reader interrupt; error code 2 signifies illegal character in word (readc.bas substitutes missing value 99999).

Figure 11b. Finished Raw Data Record, Shifted Data

17	890	-441	432	2853	890	-489	499	2896	890	-529	574	2881	890	-531	2971
-592	1532	1117	301	-592	1528	1117	312	-592	1499	1117	335	-592	1517	1117	329
589	-980	1436	3105	589	-1056	1538	3109	589	-962	1561	3094	589	-1002	1637	3153
-802	1622	1117	698	-802	1614	1117	767	-802	1606	1116	761	-892	1607	1117	756
807	-687	1131	2992	808	-739	1209	2037	809	-790	1069	2008	807	-787	1096	2993
1654	1705	1070	136	1654	1684	1070	126	1654	1687	1070	128	1654	1689	1070	122
990	-276	317	2949	990	-350	368	2926	890	-337	377	2938	890	-348	372	2945
-592	1527	1115	361	-592	1526	1115	371	-592	1532	1115	374	-592	1551	1116	369
589	-1067	1416	3052	583	-1110	1502	3067	588	-1128	1515	3095	589	-1162	1596	3095
-892	1598	1117	813	-802	1612	1117	715	-803	1626	1117	691	-802	1622	1117	679

807	-767	1079	2988	808	-795	1052	2998	807	-942	1280	3007	807	-248	1159	3006
$\boxed{1655}$	1704	1071	104	1655	1701	1071	129	1655	1695	1071	111	1655	1704	1071	111
890	-306	398	2911	890	-445	456	2911	891	-446	375	2926	890	-523	406	2938
-592	1574	1117	356	-592	1573	1117	363	-592	1585	1117	353	-592	1586	1117	352
589	-787	395	2896	589	-931	428	2950	589	-895	472	2882	589	-892	462	2869
-802	1643	1118	702	-302	1644	1118	693	-802	1641	1119	714	-802	1640	1112	729
807	-642	216	2722	809	-916	220	2798	807	-690	104	2808	807	-901	0	2794
1647	1785	1072	169	1646	1783	1072	179	1647	1787	1072	167	1647	1783	1072	165
890	-125	241	2769	890	-174	304	2762	890	-173	303	2762	890	-180	277	2763
-592	1589	1115	399	-592	1588	1115	395	-592	1598	1115	395	-592	1590	1115	403
589	-716	307	2753	589	-908	45	2725	589	-807	2	2724	589	-808	124	2719

Note: Finished raw data records after interactive data processing completed. BASIC program readc.bas has been used to properly format data. The missing value substituted because of an illegal character in block 16 of Figure 11a has been replaced with 1655 to match other tide data in burst (using TEXT EDITOR programs); this type of editing was done only in cases where the correct value for the missing data could be clearly determined.

Figure 12a. Cassette Data Record, Missing Identifier Voltage and Shifted Data

```
13          0            ce0413.a
0891-1237-0159-6361 0891-1261-0343-6363-1366 0312 0948 0017-1367 0322 0948 0016 } mid-level
-1367 0310 0948 0017-1367-0314 0948 0016 1377-0407-0605 0627 1377-1924-0743 0691 }   data
1377-1210-0984 0637 1377-1376-0548 0705-0001-0078-0048-0066-0001-0030-0023-0042 } top-level
0000-0018-0013-0034 0001-0013-0008-0031 6044-0054-0055-0045 6040-0005-0025-0026 }   data
14          0            ce0413.a
6040 0003-0018-0019 6040 0006-0016-0016 3090 0328 1139 0069 3090 0327 1141 0075 } bottom-level
3090 0328 1143 0072 3090 0327 1146 0071 0887-0925-0195-6366 0891-1369-0495-6360 }   data
0891-1121 0236-6359 0891-1120-0100-6365-1366 0213 0945 0017-1366 0210 0945 0018
-1366 0209 0944 0018-1367 0212 0944 0018 1377-1434-0600 0556 1377-1746-1634 0622
15          0            ce0413.a
1377-1009-0521 0637 1377-0934-0671 0624-0001-0070-0045-0073 0001-0025-0021 0046
0001-0012-0011-0036 0000-0011-0008-0031 6043-0043-0053-0050 6049-0003-0026-0028
6049 0003-0018-0019 6049 0005-0018-0018 3070 0220 1136 0125 3071 0222 1138 0114
3070 0229 1141 0108 3069 0239 1146 0102 0891-0695 0351-6363 0891-0838 0088-6359
16          0            ce0413.a
0891-0934-0427-6359 0888-1087-0153-6366-1366 0159 0938 0016-1366 0155 0938 0017
-1366 0158 0937 0018-1366 0157 0937 0017 1377 1055-1283 0679 1377-1711-0484 0657
1377-0813-0330 0677 1377 4360-2569 0690-0002-0075-0054-0070-0000-0026-0024-0045
-0000-0016-0014-0036 0001-0013-0010-0033 6054-0051-0057-0047 6049-0006-0026-0027
17          0            ce0413.a
6049 0001-0020-0020 6049 0004-0017-0017 3048 0157 1133 0189 3049 0157 1134 0186
3046 0156 1137 0193 3049 0157 1143 0187 0883-1592-0389-6375 0879-1542-0671-6363
0883-1521 0187-6363 0890-1195 0370-6359-1366 0136 0933 0026-1366 0136 0933 0026
-1366 0136 0933 0025-1366 0136 0933 0025 1377-1235-0236 0629 1377 0615-1307 0652
18          0            ce0413.a
1377-1006-0006 0624 1377-0938-1060 0637 0000-0069-0045-0074 0000-0025-0020-0047
0000-0016-0013-0038-0000-0011-0009-0034 6054-0046-0054-0051 -6060-0005-0026-0027
6060 0002-0019-0021 6060 0004-0016-0016 3038 0136 1128 0192 3038 0136 1130 0197
3038 0134 1132 0201 3038 0134 1134 0203 0891-0763-0111-6362 0891-1457-0144-6359
```

Note: Cassette data records as written by BASIC program readc.bas on UNIX system file. An identifier voltage has failed and the file is shifted out of the correct sequence by eight words. Data positions for top- and mid-level sensors are switched due to cabling error; top-level sensor data appears second in sequence; mid-level sensor data appears first. This file contains time voltages.

Figure 12b. Finished Raw Data Record, Missing Identifier Voltage and Shifted Data

```
  888-1083    3-6367  891-1261  -69-6360  891-1237 -159-6361  891-1261 -343-6363
    -1  -78  -48  -66   -1  -30  -23  -42    0  -18  -13  -34    1  -13   -8  -31 ] top-level data
  6044  -54  -55  -45 6040   -5  -25  -26 6040    3  -18  -19 6040    6  -16  -16 ]
 -1366  312  948   17-1367  322  948   16-1367  310  948   17-1367  314  948   16 ] mid-level data
  1377 -407 -605  627 1377-1924 -743  691 1377-1210 -984  637 1377-1376 -548  705 ]
  3090  328 1139   69 3090  327 1141   75 3090  328 1143   72 3090  327 1146   71 ] bottom-level data
   887 -925 -195-6366  891-1369 -495-6360  891-1121  236-6359  891-1120 -100-6365 ]
    -1  -70  -45  -73   -1  -25  -21  -46    1  -12  -11  -36    0  -11   -8  -31
  6043  -43  -53  -50 6049   -3  -26  -28 6049    3  -18  -19 6049    5  -16  -18
 -1366  213  945   17-1366  210  945   18-1366  209  944   18-1367  212  944   18
  1377-1434 -600  556 1377 1746-1634  622 1377-1009 -521  637 1377 -934 -871  624
  3070  220 1136  125 3071  222 1136  114 3070  229 1141  108 3069  239 1146  102
   891 -695  351-6363  891 -838   88-6359  891 -934 -427-6359  888-1087 -153-6366
    -2  -75  -54  -70    0  -26  -24  -45    0  -16  -14  -36    1  -13  -10  -33
  6054  -51  -57  -47 6049   -6  -26  -27 6049    1  -20  -20 6049    4  -17  -17
 -1366  159  938   16-1366  155  938   17-1366  158  937   18-1366  157  937   17
  1377 1055-1283  679 1377-1711 -484  657 1377 -813 -330  677 1377 4360-2569  690
  3048  157 1133  169 3049  157 1134  186 3046  156 1137  193 3049  157 1143  187
   883-1592 -389-6375  879-1542 -671-6363  883-1521  187-6363  890-1195  370-6359
     0  -69  -45  -74    0  -25  -20  -47    0  -16  -13  -38    0  -11   -9  -34
  6054  -46  -54  -51 6060   -5  -26  -27 6060 [illegible] -19  -21 6060    4  -16  -16
 -1366  136  933   26-1366  136  933   26-1366  136  933   25-1366  136  933   25
  1377-1235 -236  629 1377  615-1307  652 1377-1006   -6  624 1377 -938-1060  637
  3038  136 1128  192 3038  136 1130  197 3038  134 [illegible]  201 3038  134 1134  203
   891 -763 -111-6362  891-1457 -144-6359  891-138 [illegible]6359  890-1327   25-6365
     0  -78  -53  -73   -1  -27  -23  -48   -1  -18  -14  -40    0  -14  -11  -36
  6064  -54  -58  -49 6059   -8  -28  -28 6059   -1  -20  -21 6059    3  -17  -17
 -1366  112  927   14-1366  111  926   14-1366  111  926   14-1366  111  926   14
  1377  451 -936  527 1377 1628-1132  556 1377 -947  225  555 1377 -302 -579  515
```

Note: Finished raw data records after interactive data processing completed. The BASIC program shift.bas has been used to correctly format the data. Data positions for top- and mid-level sensors have been switched using TEXT EDITOR programs. Spurious data from sensor package with missing identifier voltage will be screened in next stage of data processing (SCREEN program).

Figure 13a. Cassette Data Record, Recorder Failure

```
55             ce0404.bed
3395 5151 4801 4748 3397 5151 4801 4748 3394 5150 4800 4748 3395 5149 4799 4748
4090 2384 2396 6891 4056 2379 2398 6835 4038 2348 2358 6861 3913 2371 2383 6696
0870 1045 1020 0936 0875 1072 1046 0962 0886 1092 1066 0981 0897 1108 1082 0996
0712 0900 0833 0647 0693 0900 0832 0649 0695 0900 0828 0646 0689 0904 0832 0651
56             ce0404.bed
5539 5318 5360 5387 5539 5318 5359 5387 5538 5318 5359 5386 5538 5317 5359 5386
4971 2298 3015 4207 5119 2914 4874 4375 4986 2263 4702 4303 5104 2933 3167 4261
3389 5152 4799 4740 3375 5149 4798 4739 3375 5148 4797 4738 3373 5148 4796 4738
4026 2808 2405 3522 4065 2366 2389 3568 3969 2388 2386 3446 3997 2355 2383 3480
57             ce0404.bed
0790 0959 0930 0846 0784 0975 0945 0861 0787 0985 0956 0872 0793 0994 0965 0881
0637 0822 0756 0592 0623 0823 0760 0599 0628 0828 0761 0601 0624 0831 0763 0605
5539 5318 5360 5387 5539 5318 5359 5387 5538 5318 5359 5387 5538 5317 5359 5386
4973 2359 3116 4248 5143 2320 3987 4370 4977 2858 4803 4332 5118 2776 3685 4281
58             ce0404.bed
3378 5149 4799 4742 3378 5149 4798 4742 3376 5148 4798 4742 3375 5148 4797 4742
4073 2363 2381 3708 3930 2391 2405 3629 3945 2358 2368 3637 4000 2347 2353 3601
0851 1033 0931 0923 0852 1056 0953 0945 0858 1070 0967 0959 0864 1081 0978 0970
0686 0880 0809 0681 0667 0881 0810 0686 0671 0885 0809 0684 0668 0889 0813 0690
59             ce0404.bed
5540 5319 5360 5388 5539 5319 5360 5388 5539 5318 5360 5387 5538 5318 5359 5387
4966 2299 3387 4268 5143 2384 4121 4422 4982 2941 5498 4336 5103 2688 5084 4320
3382 5150 4801 4743 3381 5150 4800 4743 3380 5150 4799 4743 3379 5149 4799 4742
4080 2379 2403 4064 4054 2386 2397 3991 4048 2357 2373 4075 4021 2342 2404 3869
60             ce0404.bed
0777 0949 0855 0840 0771 0965 0870 0855 0774 0976 0880 0865 0779 0985 0889 0875
0623 0816 0747 0631 0613 0817 0747 0636 0613 0827 0752 0638 0613 0826 0753 0645
5540 5320 5361 5389 5540 5319 5361 5388 5539 5319 5360 5388 5539 5318 5360 5388
4986 2293 2270 4362 5142 3048 4727 4563 4970 2505 3814 4338 5140 2333 4127 4402
61             ce0404.bed
3384 5150 4800 4741 3382 5150 4799 4740 3381 5149 4799 4740 3380 5149 4798 4739
4000 2619 2412 4310 4029 2351 2366 4309 3945 2357 2364 4228 3839 2365 2383 4235
0864 1053 1025 0942 0865 1077 1046 0966 0873 1094 1064 0582 0882 1108 1079 0997
0694 0898 0819 0722 0673 0898 0819 0726 0675 0899 0818 0723 0671 0902 0819 0728
```

Note: Cassette data records as written by BASIC program cdedit.bas on UNIX system file. Recorder failure has produced a file of spurious voltages.

Figure 13b. Finished Raw Data Record, Recorder Failure

```
99999999999999999999999999999999999999999999999999999999999999999999999999999999
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99999999999999999999999999999999999999999999999999999999999999999999999999999999
99999999999999999999999999999999999999999999999999999999999999999999999999999999
```

Note: Finished raw data records after interactive data processing completed. Spurious voltages have been replaced with "99999"s; these are interpreted as missing data in subsequent processing.

one probe system is substituted for another (a frequent occurrence), the calibration values for the individual sensors differ (almost always). This causes a bookkeeping nightmare for the data processor. It also necessitates reading and merging another cassette into monthly data files.

Briefly, the poor quality of the cassette data necessitated a tremendous effort in additional software development and preliminary data processing. An entire package of interactive software was written and utilized solely for the purpose of correctly formatting and sequencing the data (see Figure 14 and Table 7). In addition, a hardware modification (the design and installation of recorder clocks) was undertaken in an effort to more easily and accurately position the data in time. These fix-up procedures are described in more detail below.

The principal difficulties in data processing arose from the imperfect recording system and from the numerous instrument problems experienced in the field. Because these problems were largely unanticipated, data reduction proceeded much more slowly than planned.

Prior to installation and testing of the equipment it was thought the cassette data would be of sufficiently high quality such that pre-processing for the actual data reduction would be minimal. In practice, however, even the best data required a substantial amount of cleaning up. Apparently due to the recording system, the data usually did not begin in the specified pattern of six records per half-hour "reading," but rather with several spurious records. This same pattern routinely occurred at the end of the file as well. Aside from the obvious necessity to somehow delete these records, a more time-consuming and yet extremely important task was to determine the proper sequencing of the data in time. For the latter, accuracy of the field notes documenting start and end time for the cassettes was crucial. An example of a typical file beginning is shown in Figure 10a.

Another major problem centered around the format of the individual records. Oftentimes, some or all of the data would be shifted due to recorder or other hardware problems in the field, such that the data were present but in the wrong format. Since later processing depended on a standard data format, this had to be corrected. The process really became complicated when several shifts occurred throughout the file.

In these cases, the shifts would have to be found and interpreted, the file split, and the individual parts shifted into proper sequence. This was often quite time-consuming, especially as the project progressed and the equipment began to deteriorate. Examples of data shifts can be found in Figures 11a and 12a.

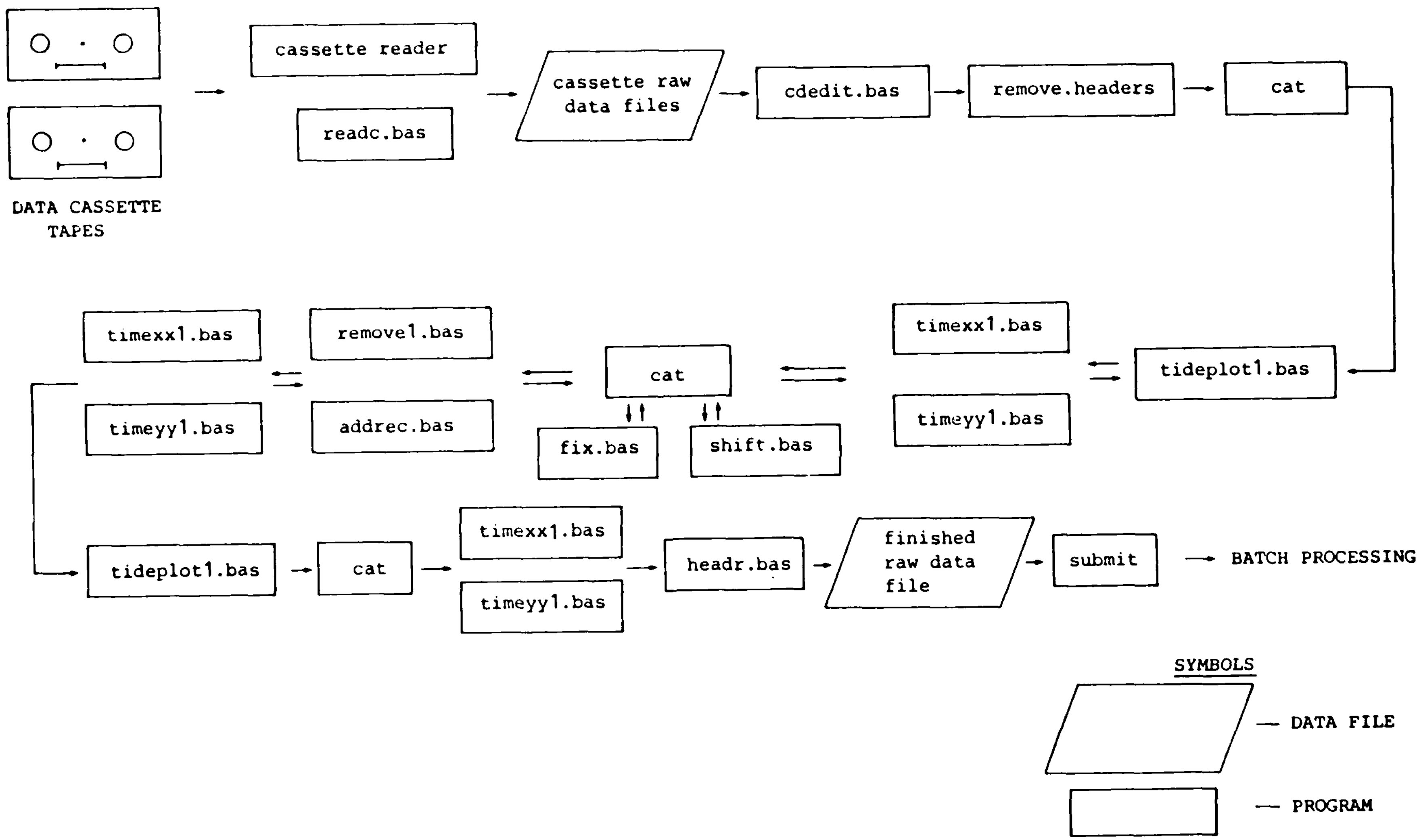


Figure 14. Detailed Flow Scheme of Interactive Data Processing

Table 7. Descriptions of Interactive Data Processing Programs

Procedure Name	Duty
readc.bas	BASIC program. Reads data from cassette record into UNIX file. Words containing illegal characters are converted to missing words (99999).
cdedit.bas	BASIC program. User scans cassette blocks by keying on questionable blocks identified by readc.bas. 'Bad' blocks are replaced by missing words (99999) or shifted blocks are corrected. This procedure is used to correct problems related to faulty data recording, i.e., tape interrupts.
remove.headers	UNIX system shell script. Removes cassette data block header records.
cat	UNIX system utility to view file.
tideplot1.bas	BASIC program. CRT character plot of tidal heights. The plot is used interactively to check record sequencing and correct placement of data records in time.
timexx1.bas; timeyy1.bas	BASIC programs. Conversions between record counts and time (hour, Julian day, year).
shift.bas	BASIC program. Writes corrected output file by shifting word positions so as to bring data into correct sequence.
fix.bas	BASIC program. Substitutes identifier voltages and adjusts current meter sensor corrections (volts to cm/sec) when field equipment is changed in 'mid cassette.' This procedure is also used when an identifier voltage has failed or has been temporarily substituted by a depth reading.

Table 7 (continued)

Procedure Name	Duty
addrec.bas; remove1.bas	BASIC programs. Add or remove data records (added records consist of missing words, 99999) from data files to preserve sequence.
headr.bas	BASIC program. Write batch computer system job control language and raw data tape header block.
submit	UNIX system utility to transfer data files to batch processing system.

Instrument failures required an additional outlay of data processing labor, and these failures occurred frequently. Since the identifier voltages and current sensor calibration values differ for each probe system, changing probes midway through a tape caused severe problems. The batch data processing screening software checked identifier voltage and applied the appropriate current corrections. When an instrument was changed in mid-cassette, interactive programming was required to "simulate" the old instrument by correcting current sensor readings and substituting the correct identifier voltages. Some instrument failures had been anticipated and planned for, but the frequency of instrument failure was much higher than expected, and this in turn greatly increased the amount of effort needed for data processing.

Occasionally, various problems with the recorder would occur in the field. If this resulted in jams and scattered garbage characters, a great deal of time and use of the text editor was necessary to correctly format the data. Sometimes, however, no usable data was recorded and therefore a dummy file was created. Figures 13a and 13b are examples of this type of file.

Data reduction and graphic production procedures also underwent modification. However, compared to those modifications necessary to prepare the data for the LBL processing, these changes were relatively minor. Details of these latter procedures and programs are contained in the User's Manual for the Physical Data Display Package at Lawrence Berkeley Laboratory.

The final stage in evolution of the file management procedure followed the guidelines of our initial scheme but had certain modifications and additions. The overall flow scheme of the data processing is as shown in Figure 15. Briefly, the procedure was as follows:

A. Procedure to Screen and Process Cassette Data

1) Field books kept and copies of field sheets (Appendix 2) used extensively in determining time sequencing of the data, in understanding data problems, and as sources of ground truth information.

2) Preliminary Data Screening and Processing; Producing Raw Data Files (Refer to Figure 14 and Table 7).

a. Cassette files input into the interactive computing system (UNIX) via cassette reader designed for this purpose. Preliminary

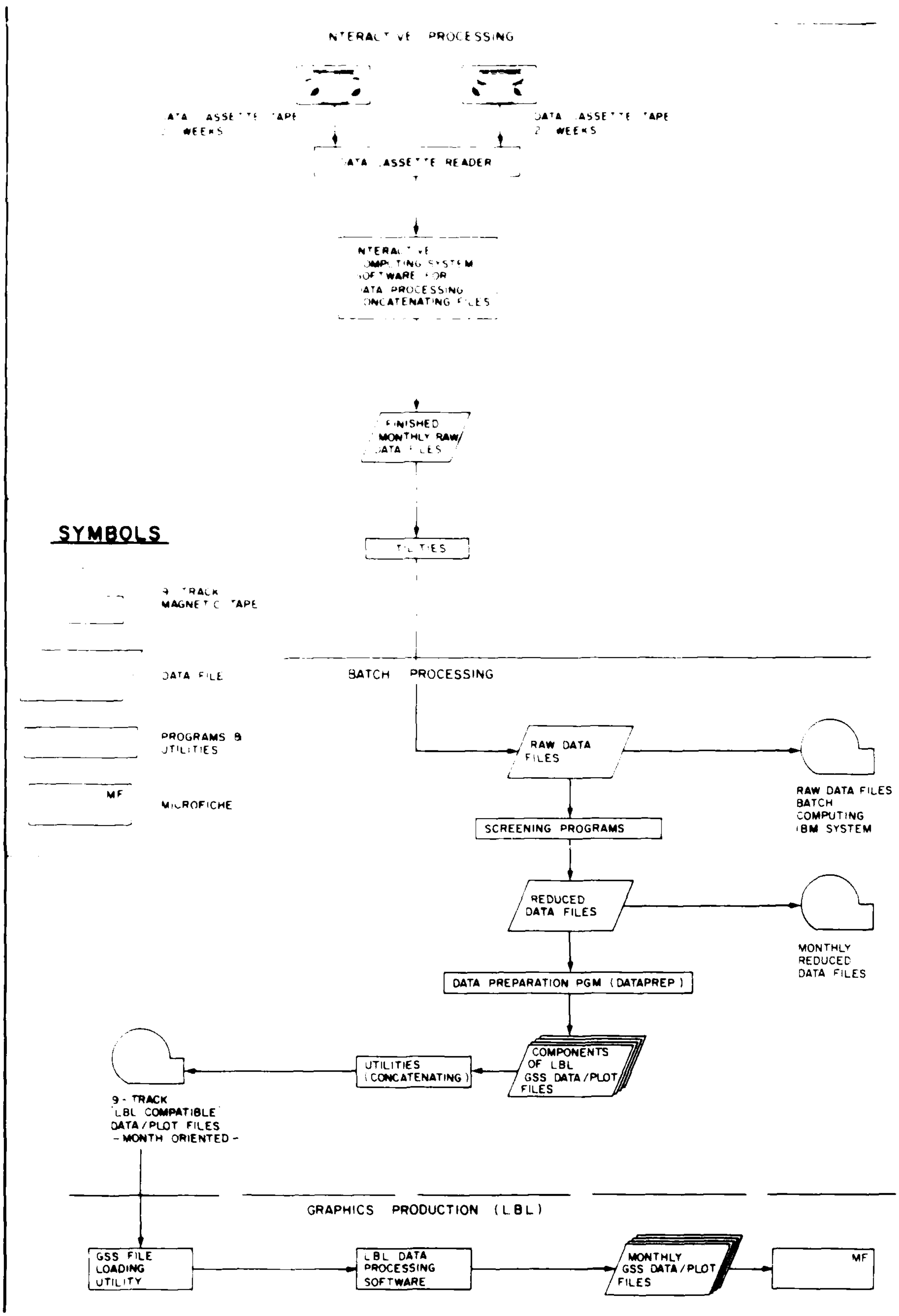


Figure 15. Overall Flow Scheme of Data Processing

scanning of data to detect obvious equipment malfunction. Files written on 9-track magnetic tapes for permanent file storage.

b. Cassette files loaded into disc files and run through interactive processing procedures to format data and sequence in time. Field notes used as reference. Preliminary data screening for bad characters.

c. Two files (two weeks each) for each station concatenated to create the required monthly data file; header written and added to beginning of file. Completed monthly raw data files for all six stations written on 9-track magnetic tape for back-up.

d. Raw data files transferred to the batch processing environment via a UNIX utility program utilizing another 9-track magnetic tape. (See next section for description of these programs).

3) Data Screening and Preparation for Graphics Production; Producing Reduced Data Files (Refer to Figure 16 and Table 8).

a. Raw data files run through SCREEN program. Data screened for extreme values. Program also rotates axes, transforms data, (vector) averages and applies specific corrections for the individual current meters, generates time code, counts and writes output records. Output scanned by user and evaluated for data or instrument problems.

b. Reduced data written onto 9-track magnetic tape. These data constitute "Reduced Data Tape" of specifications.

c. Reduced data prepared for plotting by DATAPREP program. Plot array files created for each physical parameter. Files written on 9-track magnetic tape for transfer to Lawrence Berkeley Laboratory GSS system.

B. Procedure for Graphics Production (See Figure 17 and Tables 9 and 9a).

Production of graphics at Berkeley is greatly aided by the sophistication of the Lawrence Berkeley Laboratory (LBL) facilities. The LBL facilities make it a routine matter to produce 35 or so microfiche in two days for a month of data.

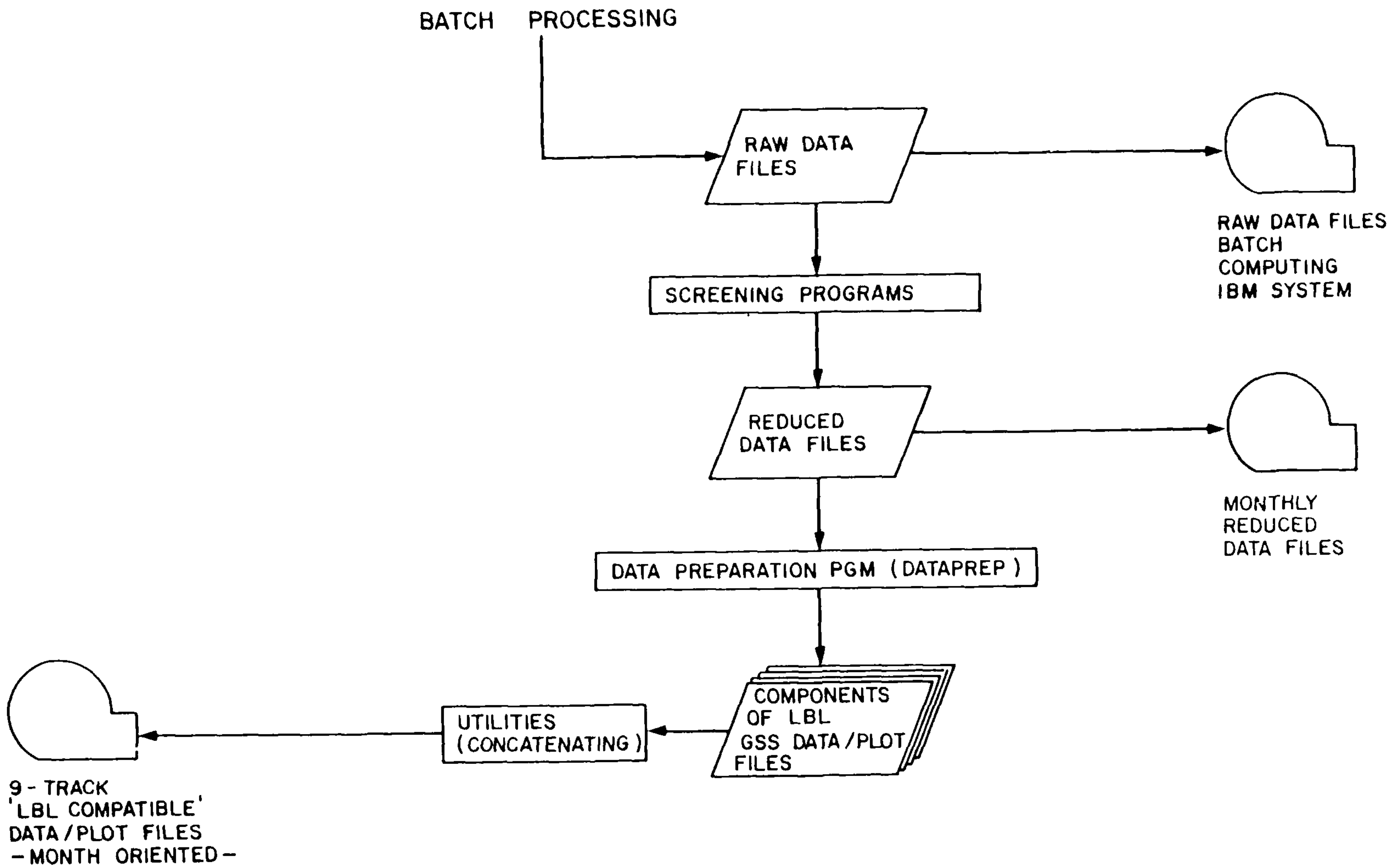


Figure 16. Flow Scheme of Batch Data Processing

Table 8. Descriptions of Batch Data Processing Programs

Procedure Name	Duty
SCREEN	Fortran program. Create file of screened data from raw data file.
SCREEN (Grizzly Bay version)	Fortran program. Create file of Grizzly Bay screened data from Grizzly Bay raw data file.
DATAPREP	Fortran program. Create plot array files for each physical parameter.
DATAPREP (Grizzly Bay version)	Fortran program. Create plot array files for each physical parameter from Grizzly Bay data.
IEBGENER	IBM system utility to concatenate files.

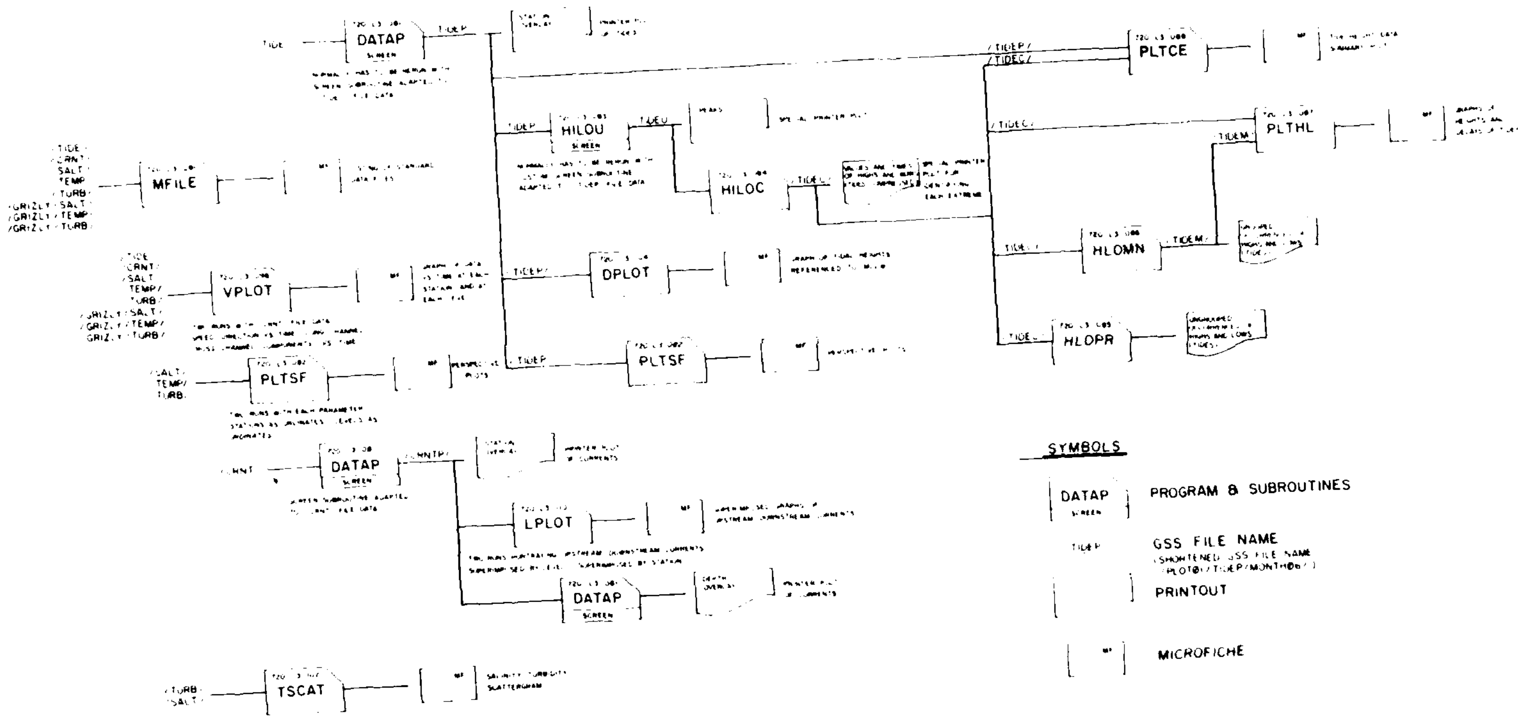


Figure 17. Detailed Flow Scheme of Graphics Production (LBL) Data Processing

Table 9. Descriptions of Graphics Production (LBL) Data Processing Programs*

Procedure Name	Duty
MFILE	Produces an image on microfiche of a full printout of the plotfiles for each variable. The fiche so generated usually form the most convenient basis for looking up a specific data value.
VPLOT	Produces graphs on microfiche of each variable *versus* time. In the case of currents, two different displays are generated: speed and direction *versus* time, and long-channel and cross-channel speed components *versus* time.
PLTSF	Produces perspectives on microfiche of salinity, temperature, turbidity and tide, the x-axis being time, the y-axis being either station (5 values) or depth (3 values), and the z-axis being the data.
LPLOT	Produces overlaid graphs on microfiche of upstream-downstream currents *versus* time. Currents can be overlaid by depth or by station.
TSCAT	Produces a scattergram on microfiche of turbidity *versus* salinity.
DATAP	A general purpose data screening program that also produces graphs of tide height or current in printer-plot fashion. As a part of producing one of the current printer-plots, it also generates a current file used by LPLOT.

*The suite of programs that can be used at Lawrence Berkeley Laboratory for the generation of microfiche is fully described in the *San Francisco Bay-Delta Estuary Physical Data Display Package User's Guide*. This table gives a brief description of each program.

Table 9 (continued)

Procedure Name	Duty
HILOU	Produces printer-plots of tide highs and lows. In particular it permits the suppression of spurious highs and lows (due to equipment malfunction) that would otherwise interfere with later programs.
DPLOT	Produces microfiche of tide heights relative to MLLW versus time.
HILOC	Produces a compressed data file containing information on the times, values, and type (Higher-high, Lower-high, etc.) of each high or low water.
HLOPR	Produces a printout showing the time of occurrence of every high and low water.
HLOMN	Produces a printout, similar to HLOPR, but showing occurrences of grouped high and low waters, each having a common mean. The datafile so produced is used in the plotting of PLTHL below.
PLTCE	Produces microfiche containing contours of tide height versus time and station, having superimposed on them the times of occurrence of high water and low water.
PLTHL	Produces microfiche containing the time of occurrence and value of: higher-highs, lower-highs, highs (any type), higher-lows, lower-lows, lows (any type).

Table 9a. SCREEN Selections

Data Type	Amplitude	Uncertainty Factor	y
Tide height	60 cm	4	61 cm
Current speed	200 cm s^{-1}	8	405 cm s^{-1}
Salinity	10 o/oo	3	7.6 o/oo
Temperature	3°C	4	3°C
Turbidity	50%	8	101%

When files are received at LBL, the data are assumed to be correctly positioned in time, and screened to the extent that misleading data at the start and end of a record have been removed. Missing data will have been set equal to 9999.9. Not extracted from the data are "noisy" data, since different end users may have different criteria for what constitutes noise.

With the exception of tide records, for which further special handling is required (see below), the standard method of screening data at LBL is to compute a maximum tolerable jump per time step. At the start of a program, the user specifies the amplitude "A" of the expected phenomenon (considered to be a sinusoidally varying quantity of period 12.42 hours), and also specifies an "uncertainty" factor "U". If the likely instantaneous value of the data is then expressed by

$$y = A \sin \frac{2\pi t}{T},$$

where "T" is the period, then the maximum rate of change is given by $2\pi A/T$. The maximum permitted change in the data, per single time step of Δt will thus be $2\pi AU\Delta t/T$. Since missing data can span more than one time step, data separated by $n\Delta t$ are tested for changes greater than $2\pi AUn\Delta t/T$. If the change is greater than this value, the data point is set equal to 9999.9. The method is of course primitive but understandable. Future investigators can easily supply their own SCREEN subroutines.

Standard selections for A (amplitude) and U (uncertainty factor) for the various data types are shown in Table 9a along with the resulting quantity Δy ($2\pi AU\Delta t/T$, with Δt = 1/2 hour and T = 12.42 hours). It should be noted that this form of screening only takes place in the perspective and contouring programs, not in the scalar curve-plotting programs (with the one exception of the MLLW tide plot).

Tide data undergo additional screening by hand due to the need to compute times of high and low water. (If care is not taken, any change of sign of slope will be taken as indicating a high or a low; whereas in reality it may only be associated with a noisy record.) A program is run which highlights every high and low, whether real or not. It is then the user's responsibility to alter those noisy values that caused false highs or lows.

The avoidance of confused plots arising from noisy data is handled in a fairly routine manner. No problem is encountered during graph drawing, and the problem of missing data in contour or perspective displays merely requires the selection of a sophisticated program.

Probably the chief problem in handling data at LBL arises from slowly failing sensors. When this happened with tides, the approach generally taken was to make use of the times of the highs and lows, but to ignore the heights.

Typically a user arrives at LBL with a single 9-track IBM-compatible magnetic tape. This tape must then be converted to CDC-compatible form and subsequently stored on the LBL high-density GSS tape system. Since this procedure is slow it is best that this first job submission be made during the evening preceding the two-day work session.

After checking that the files have been successfully loaded, a typical session starts by submitting groups of jobs (1) to provide print-image on microfiche of the actual data values, and (2) to produce simple graphs of all parameters versus time. Also produced at this time are the somewhat more complicated current plots. A step that can be performed nearly simultaneously with the tasks above is that of producing perspective plots. It should be noted that the major task of the user is to produce perfect control cards that specify file names and microfiche titles; the smallest mistake at this stage results in errors of the type where the wrong month is placed in the microfiche title.

The remaining steps are more complex, if only because jobs must be run in a fixed sequence, and checks must be made at certain points to ensure error-free work. The complexity of the process is illustrated in Figure 17 which shows the job submission sequence, data path names, and nature of the output. The process is described in detail in the LBL User's Guide. The two main types of data processing at this stage are currents and tides. The former require processing first into upstream/cross stream components. This is followed by jobs that display currents either overlaid by depth (i.e., for each station, currents for the five stations are displayed simultaneously). These forms of display permit the user to answer questions of the type "What is the delay of the time of maximum flood current at each station?" The tidal display process is more complex and time-consuming. In addition, to ensure that there are no false highs or lows resulting from noisy data, the highs and lows themselves must be grouped together for the purpose of contouring. Lastly, in two separate display jobs, two data sets are combined together so as to provide the user with information both on the quality of the tide data, and on the highs and lows.

Typically, by the start of the morning of the second day one should have available microfiche of all quantities but tides and overlaid currents. Also available at this time should be a printout of the individual highs and lows.

With luck only small changes will be required to correct the graphics or noisy tide data. If so, the microfiche will usually be available by early afternoon.

Recorder Clocks

Because the positioning of the data in time was often difficult to determine, yet crucial to further processing and interpretation, an attempt was made to solve this problem directly by inserting an independent, absolute time value on the actual cassette tape records themselves. In the fall of 1979, discussion between KLI, Corps personnel, and InterOcean representatives led to the design and installation of recorder clocks.

The clocks were to have the following properties:

1) The "time" must be knowable, i.e., one must be able to interrogate the clock or "tell time."

2) The clock must be capable of being set to a desired value.

3) The clock must increment (change time) on time.

4) The clock must have an independent power supply.

The clocks were installed in October 1979 during the period in which the sensors were out of the water for servicing and calibration. Initial testing as well as actual field performance produced unsatisfactory results, however. The clocks could not be precisely set, nor was their timekeeping sufficiently accurate or reliable to be of much use. A detailed description of these problems along with hard-copy documentation of actual data records was sent to InterOcean but no action was taken by them to correct or improve clock performance.

In practice, the clocks were used in a limited fashion to sequence data within a file and as a check when determining start and end times by qualitative means. While this was useful, it came nowhere near initial expectations for level of performance.

RESULTS

Fifteen months of data collected over the period February 1979 through June 1980 have been processed and reduced. Additional data have also been acquired during the period July 1980 through January 1981 by the U.S. Geological Survey with financial support by the state Department of Water Resources and the federal Water and Power Resources Service and with operational support provided by KLI. Raw and reduced data for the initial 15 months have been written onto 9-track magnetic tapes. Final graphical displays of data in microfiche form have been submitted to the government as they were produced throughout the project period.

Data gaps occurred sporadically throughout the duration of the project as indicted in the summary presented in Table 10. The primary causes of data loss fell into two categories: equipment failure or malfunction and outside interference such as vandalism or collision. Equipment problems were by far more common but generally resulted in only partial rather than complete data loss for a particular station. An exception was when malfunction occurred in the recorder, in which case all data would be lost. Complete data loss also occurred when a recording system was damaged or destroyed by outside interference.

If an individual sensor on a probe failed, data loss was usually restricted to that parameter. Even though biweekly checks on sensor conditions were carried out, subtle cases of sensor malfunction were sometimes not detected until data processing was complete. Failure of an entire probe system at one or several levels was more obvious and the situation thus more quickly remedied, except when spare parts or probes were not available. In that case, data gaps continued until the repair could be effected. Recorder problems were by far the most serious type of equipment failure since data from all three levels were affected. Files filled with jams or spurious voltages or short files due to excessive battery drainage because of shorts in the circuit boards are examples of data losses that could be caused by the recorder, even when it still seemed to be functioning correctly during field checks.

Three stations experienced data loss due to outside interferences. Stations 3 and 4 at Benicia and Port Chicago, respectively, were hit, presumably by a vessel, and necessitated repair of equipment. Another collision occurred at Port Chicago but with minimal data loss and no major damage to equipment. Station 1, at San Pablo Bay, was subject to an apparent act of vandalism which resulted in the station being out of operation for over two months due to a lack of available spares at that time (Appendix 5).

Table 10. Summary of Data Recovery by Month

Station	Time Periods (1979)			
	8,15 February-28 February	28 February-19,20 March	19,20 March-4 April	4 April-19,20 April
Station I San Pablo	---	---	Unusable data: 20 March-22 March Missing data: 22 March-4 April Code B (A)	Missing data: 6 April-19 April Code B(A)
Station 2 Carquinez Strait	---	Unusable data: 17 March-19 March Code B,(A)	No usable data for entire period Code B,(A),C	No usable data for entire period Code B,(A),C
Station 3 Benicia	---	Unusable data: 14 March-20 March Code B,(A)	---	---
Station 4 Port Chicago	---	---	---	---
Station 5 Chipps Island	---	Unusable data: 14 March-20 March Code B,(A)	---	---
Station 6 Grizzly Bay	---	---	---	---

Codes: A - battery failure
B - recorder malfunction
C - sensor malfunction
D - cable/connector malfunction
E - no obvious equipment malfunction
--- - complete data recovery

Table 10 (continued)

Station	Time Periods (1979)			
	19,20 April- 2 May	2 May 17,18 May	17,18 May- 31 May	31 May 13,14,15 June
Station 1 San Pablo	---	---	---	---
Station 2 Carquinez Strait	Unusable data: 19 April- 27 April Code B,(A)	---	---	---
Station 3 Benicia	---	---	---	---
Station 4 Port Chicago	No usable data for entire period Code A,C	No usable data for entire period Code B,C,D	Unusable data: 18 May-31 May Code B,C,D	Missing data: 31 May-14 June Code B
Station 5 Chipps Island	---	---	---	---
Station 6 Grizzly Bay	---	---	---	---

Codes: A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
--- = complete data recovery

Table 10 (continued)

Station	Time Periods (1979)			
	13,14,15 June-27 June	27 June-13,17,18 July	13,17,18 July-6 August	6 August-22,23 August
Station 1 San Pablo	---	---	---	---
Station 2 Carquinez Strait	---	Missing data: 17 July Code C	---	---
Station 3 Benicia	---	---	---	---
Station 4 Port Chicago	No usable data for entire period Code E	No usable data (missing data for 6½ days) Code B,C	Missing data: 26 July-6 August Code B	Missing data for #1 & #3 sensors Code C Missing data for #2 sensor 19-23 August Code B
Station 5 Chipps Island	---	---	---	---
Station 6 Grizzly Bay	---	---	---	---

Codes:
A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
--- = complete data recovery

Table 10 (continued)

Station	Time Periods (1979)			
	22,23 August- 17 September	17 September- 2,3 October *	2,6 November- 27,28 November	27,28 November- 11,12 December
Station 1 San Pablo	---	---	Missing data: 27 November Code F	---
Station 2 Carquinez Strait	Missing data: 17 September Code F	---	No usable data for entire period Code B	Unusable data: 27 November- 4 December Code B
Station 3 Benicia	---	Unusable data: 29 September Code B(A) Missing data: 30 Sep-3 Oct Code B(A)	Missing data: 27 November Code F	Missing data: 11 December Code B(A)
Station 4 Port Chicago	Missing data for #1 sensor for entire period Code C Missing data: 5 Sep-17 Sep Code B	Missing data for #1 sensor: 17-20 September Code C Missing data: 30 Sep-2 Oct Code B	Missing data: 28 November Code F	---
Station 5 Chipps Island	Missing data: 31 August- 17 September Code B(A)	Unusable data: 17-20 September Code B(A)	Missing data: 27 November Code F	Unusable data: 4-12 December Code B(A)
Station 6 Grizzly Bay	---	---	---	---

Codes: A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
F = data cassette overflow
--- = complete data recovery

* Calibration occurred between 3 October and 2 November 1979

Table 10 (continued)

Station	Time Periods (1979-1980)			
	11,12 December-26-27 December	26,27 December-10,11 January	10,11 January-29,30 January	29,30 January-14 February
Station 1 San Pablo	---	---	Missing data: 15-30 January Code G	Missing data for entire period Code G
Station 2 Carquinez Strait	Unusable data: 12-27 December Code B	---	Missing data: 13-29 January Code B(A)	Missing data: 30 Jan-14 Feb Code B
Station 3 Benicia	---	---	---	---
Station 4 Port Chicago	---	Missing data for #1 sensor for entire period Code C Missing all data: 4-11 January Code G	---	---
Station 5 Chipps Island	---	Missing data: 10 January Code B(A)	---	Unusable data: 14 February Code B
Station 6 Grizzly Bay	---	---	---	---

Codes: A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
F = data cassette overflow
G = station vandalized, hit
--- = complete data recovery

Table 10 (continued)

Station	Time Periods (1980)			
	14 February-26,27 February	26,27 February-12 March	12 March-21,25 March	21,25 March-10 April
Station 1 San Pablo	Missing data for entire period Code G	Missing data for entire period Code G	Missing data for entire period Code G	Missing data: 8-9 April Code F
Station 2 Carquinez Strait	---	---	---	---
Station 3 Benicia	---	---	---	---
Station 4 Port Chicago	Missing data: 22-27 February Code B	Missing data for entire period Code B	---	Missing data for entire period Code B
Station 5 Chipps Island	---	---	---	---
Station 6 Grizzly Bay	---	---	---	---

Codes: A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
F = data cassette overflow
G = station vandalized, hit
--- = complete data recovery

Table 10 (continued)

Station	Time Periods (1980)		
	10 April 28,30 April	28,30 April- 16,19 May	16,19 May- 2 June
Station 1 San Pablo	---	Missing data for entire period Code B	Missing data for entire period Code B
Station 2 Carquinez Strait	Unusable data: 25-28 April Code B	---	---
Station 3 Benicia	---	---	---
Station 4 Port Chicago	Unusable data: 21-30 April Code B	Unusable data for entire period Code B	---
Station 5 Chipps Island	---	---	Missing data: 25 May-2 June Code B
Station 6 Grizzly Bay	---	---	---

Codes: A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
F = data cassette overflow
G = station vandalized, hit
--- = complete data recovery

Table 10 (continued)

Station	Time Periods (1980	
	2 June- 19,20 June	19,20 June- 2,3 July
Station 1 San Pablo	Missing data for entire period Code B,D	Unusable data for entire period Code B,D
Station 2 Carquinez Strait	---	---
Station 3 Benicia	---	---
Station 4 Port Chicago	---	---
Station 5 Chipps Island	---	---
Station 6 Grizzly Bay	---	---

Codes: A = battery failure
B = recorder malfunction
C = sensor malfunction
D = cable/connector malfunction
E = no obvious equipment malfunction
F = data cassette overflow
G = station vandalized, hit
--- = complete data recovery

Overall, data recovery was about 67 percent, representing approximately 1.8 million data points. The data recoveries achieved per station by month and by parameter are shown in Tables 10 and 11.

Tables 12 and 13 provide a guide to the storage system for the large amount of data generated by the project. Figure 18 illustrates the raw data file format and header of the 9-track tape files. Examples of microfiche plots of the resulting data are shown in Figures 19 through 34.

Table 14 is a catalog of the data tapes produced by the project. This table can be consulted by data users in order to guide them to the data tapes of interest.

Table 11. Data Recovery by Parameter

Station Number	All Parameters	Tide	Salinity	Temperature	Turbidity	Currents
	Percentage of Data Recovered*					
1	74	90	71	76	59	76
2	59	69	52	68	49	62
3	84	83	86	90	69	87
4	41	46	40	46	44	45
5	70	73	81	80	36	75
6	68	--	85	85	34	--
Average	66	72	69	73	49	69

*Note: Estimated as percentage of 4012 five-day frames of microfiche data according to: % Data = (# of Full Frames + 1/2 # of Partial Frames)/Total Frames.

Table 12. Data Storage System Per Month of Data

Data Type	Filename Format	Storage Mode
raw cassette data	ceøxyy.a, ceøxyy.b* (12 files, by station)	cassette tapes (12/mo)
finished raw data with header	ceøxyy.fin (6 files, by station)	9-track magnetic tape*** (1/mo)
reduced data	ceøxyy.screen (6 files, by station)	9-track magnetic tape (1/mo)
plot data	PLOTOX/SALT/MONTHYY** (6 files, by parameter)	9-track magnetic tape (1/mo)
plot files	PLOT01/SALT/MONTHYY PLOT01/GRIZLY/SALT/MONTHYY	GSS Tape 37734 magnetic tape

* x = station number (1-6), yy = month of data (sequential).

** SALT represents salinity data.

*** 9-track magnetic tape characteristics: 800 BPI
ASCII
LRECL=80
BLKSIZE=1600

Table 13. Permanent File Structure Summary

<table>
<tr><th>RAW DATA FILES</th><th>REDUCED DATA FILES</th><th>PLOT DATA FILES</th></tr>
<tr><td colspan="3">Header Characteristics:</td></tr>
<tr><td>20 80 character records

1 FILE HEADER BLOCK
2 U.S. ARMY CORPS OF ENGINEERS
3 SCREENED DATA FILE
4 GRIZZLEY BAY STATION
5
6 6=STATION CODE
7 100=GMT START
8 41=JULIAN DAY START
9 1979=YEAR START
10 1600=GMT END</td><td>11 78=JULIAN DAY END
12 1979=YEAR END
13 6=FILE NUMBER
14 2=TAPE NUMBER
15 1=REEL NUMBER
16 2=TAPES IN SUBMITTAL
17 1807 RECORDS
18
19
20 HEADER BLOCK FORMAT
2H ,I8,I8,10A4</td><td>7 80 character records

3 records: numerical keys describing characteristics of contained data arrays.
3(10I8);
4 records: plot captions.
4(8A10)</td></tr>
<tr><td colspan="3">Data File Characteristics:</td></tr>
<tr><td>6N 80 character records

Data from 3 instruments @ 2 records/instrument: 4(4-tuple) of -ID, conductivity, temperature, turbidity; 4(4-tuple) of +ID (or tide), V_x (current), V_y (direction.
3(2(16I5))</td><td>3N 80 character records

<table><tr><th>Columns</th><th>Datum</th><th>Format</th></tr><tr><td>1-3</td><td>Station Code</td><td>I3</td></tr><tr><td>4-5</td><td>Depth Code</td><td>I2</td></tr><tr><td>6-8</td><td>Depth (meters)</td><td>I3</td></tr><tr><td>10-13</td><td>GMT</td><td>I4</td></tr><tr><td>15-16</td><td>Day</td><td>I2</td></tr><tr><td>17-18</td><td>Month</td><td>I2</td></tr><tr><td>19-20</td><td>Year</td><td>I2</td></tr><tr><td>21-28</td><td>Current Speed</td><td>F 8.2</td></tr><tr><td>29-36</td><td>Current Direction</td><td>F 8.2</td></tr><tr><td>37-44</td><td>Salinity</td><td>F 8.2</td></tr></table>
3(2I2,I6,I5,I4,4H 19,I2, 6F8.2,I8)</td><td>80 character records

Plot data array characteristics defined by header record numerical keys; data from each station separated by header records (these include station specific plot captions); single parameter file (e.g., salinity).

Usual single record format: (10F8.2)</td></tr>
</table>

```
     1        FILE HEADER BLOCK
     2        U.S. ARMY CORPS OF ENGINEERS
     3        RAW DATA FILE
     4        SAN PABLO BAY
     5
     6          1=STATION CODE
     7     2330=GMT START
     8        78=JULIAN DAY START
     9     1979=YEAR START
    10     1830=GMT END
    11       109=JULIAN DAY END
    12     1979=YEAR END
    13          1=FILE NUMBER
    14          2=TAPE NUMBER
    15          1=REEL NUMBER
    16          2=TAPES IN SUBMITTAL
    17     8874 RECORDS
    18
    19
    20        HEADER BLOCK FORMAT 2H ,I8,I8,10A4
-0592 2248 1257 2368-0592 2211 1257 2405-0592 2239 1258 2403-0592 2236 1257 2395
 0588-1005 0091 2373 0588-1103-0052 2349 0589-1114-0072 2303 0589-1072-0116 2317
-0802 2471 1244 1928-0802 2465 1244 1930-0802 2492 1244 1843-0802 2467 1244 1995
 0807-0990-0150 2414 0807-1113-0173 2394 0807-1036-0119 2375 0807-1072-0234 2359
 2757 2499 1276-0000 2757 2500 1276-0000 2757 2501 1276-0000 2757 2501 1276-0000
 1079-0506-0246 2215 1079-0558-0332 2197 1079-0534-0356 2190 1079-0574-0379 2179
-0592 2243 1256 2401-0592 2243 1256 2412-0592 2244 1256 2424-0592 2243 1256 2433
 0588-1192-0386 2319 0589-1186-0455 2291 0589-1139-0588 2292 0589-1215-0475 2292
-0802 2487 1244 1603-0802 2475 1244 1639-0802 2487 1244 1604-0802 2506 1243 1636
 0807-0665-0168 2303 0807-0748-0221 2303 0808-0689-0368 2267 0807-0616-0413 2269
 2803 2531 1275-0000 2803 2531 1274-0000 2803 2531 1275-0000 2803 2530 1275-0000
 1079-0341-0238 2133 1079-0492-0222 2147 1079-0460-0273 2133 1079-0461-0272 2119
-0593 2358 1253 2245-0593 2334 1253 2248-0592 2315 1253 2256-0592 2308 1254 2256
 0589-0907-0305 2348 0589-0975-0384 2364 0589-0955-0395 2348 0589-0962-0354 2348
-0802 2579 1239 1662-0802 2581 1239 1677-0802 2580 1239 1639-0802 2578 1239 1631
 0807-0567-0258 2339 0807-0655-0286 2348 0808-0824-0159 2347 0807-0824-0165 2361
 2833 2586 1272-0000 2832 2586 1272-0000 2832 2586 1272-0000 2832 2587 1272-0000
 1079-0486-0197 2221 1079-0629-0230 2201 1079-0585-0296 2160 1079-0552-0333 2119
```

Figure 18. Completed raw data file with 20-line header block and all words properly sequenced.

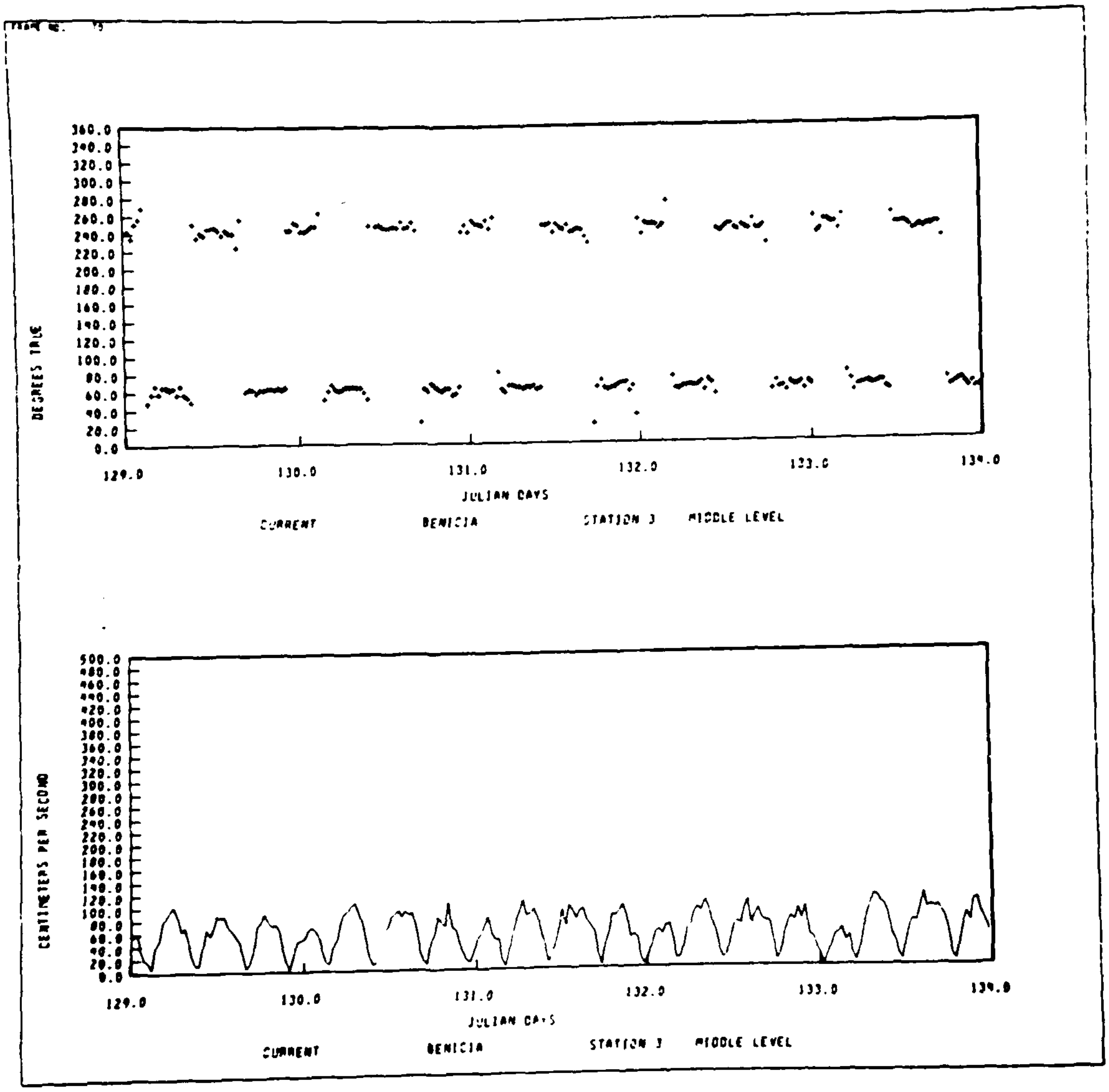
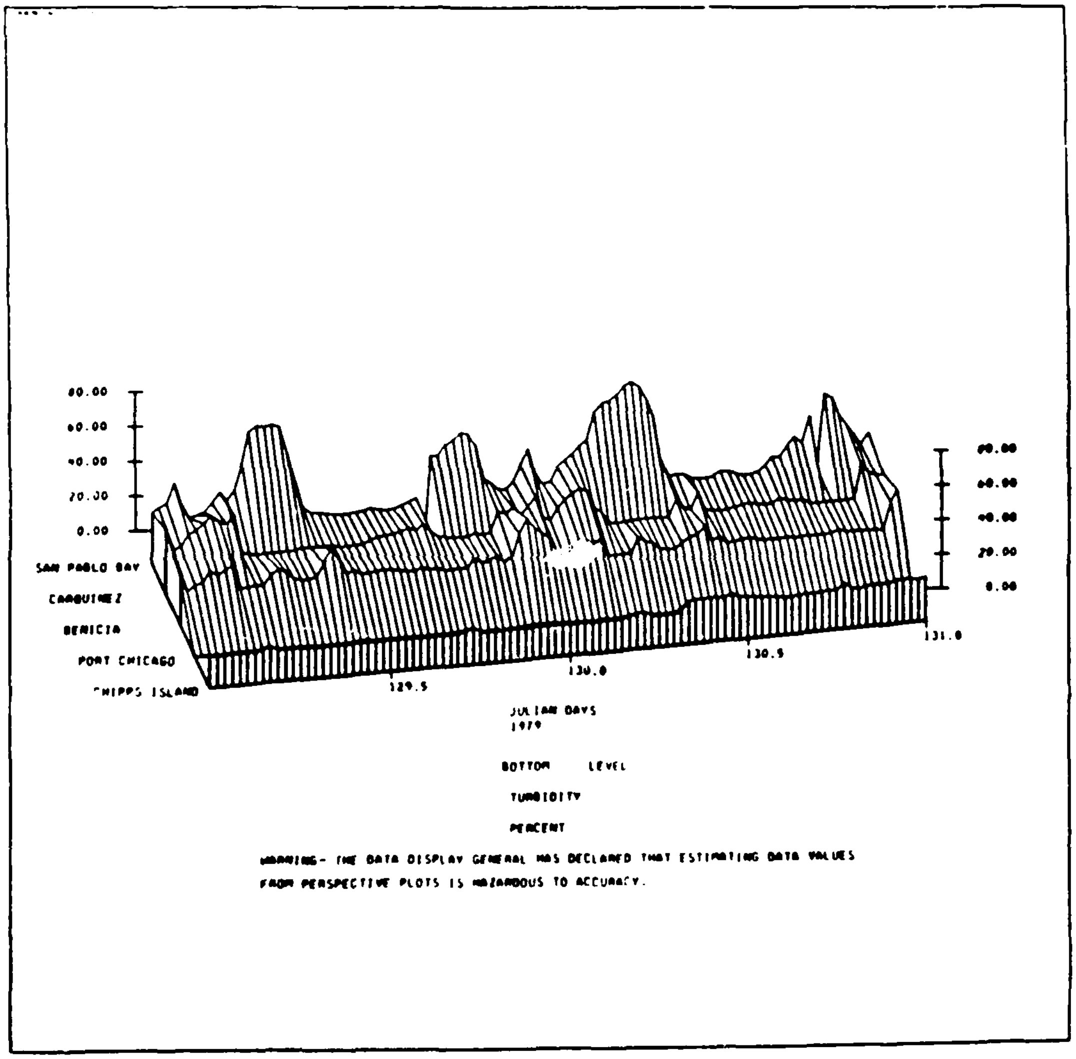


Figure 19. Microfiche Plot - Currents, Benicia



<u>Figure 20</u>. Microfiche Plot - Turbidity, Bottom Level

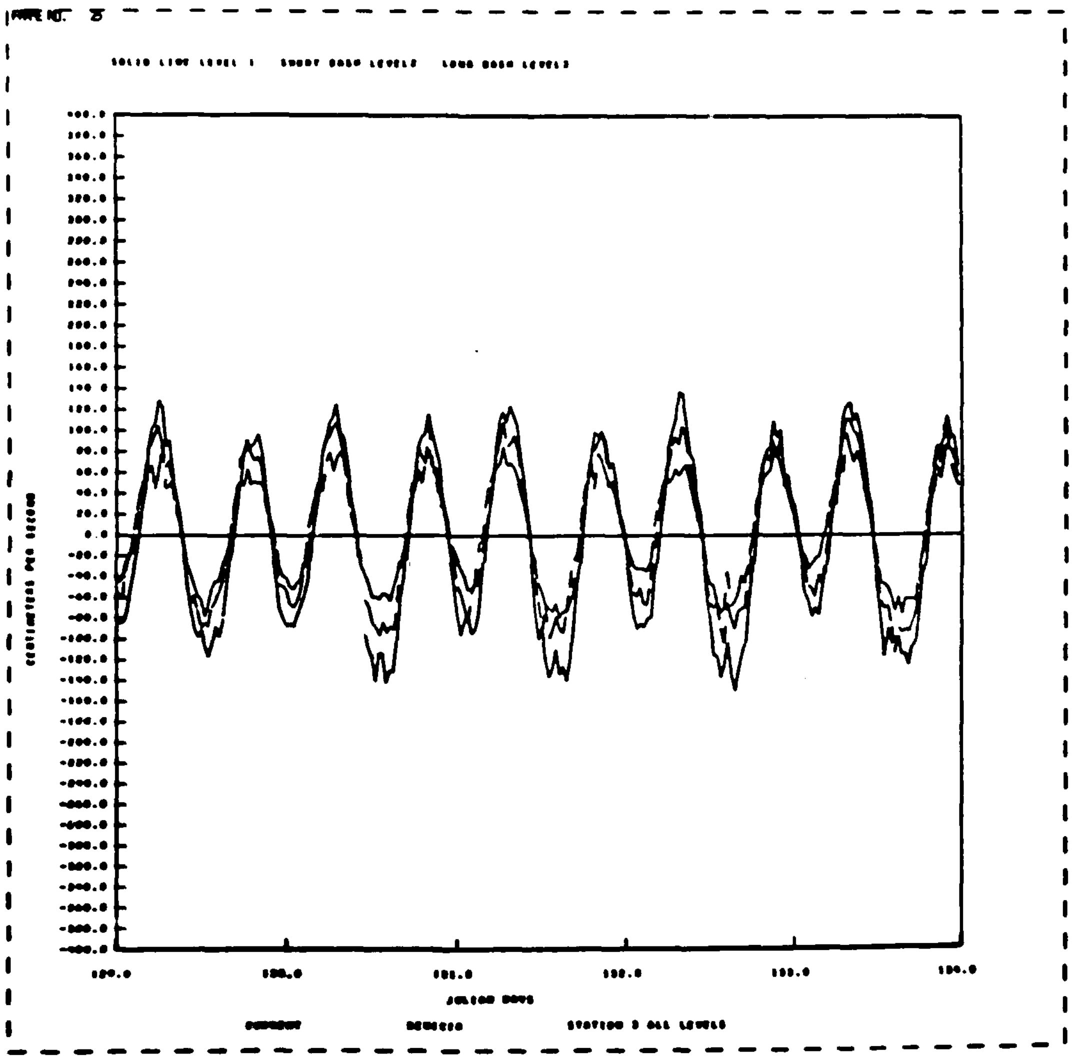


Figure 21. Microfiche Plot - Up and Down Channel Currents, Benicia

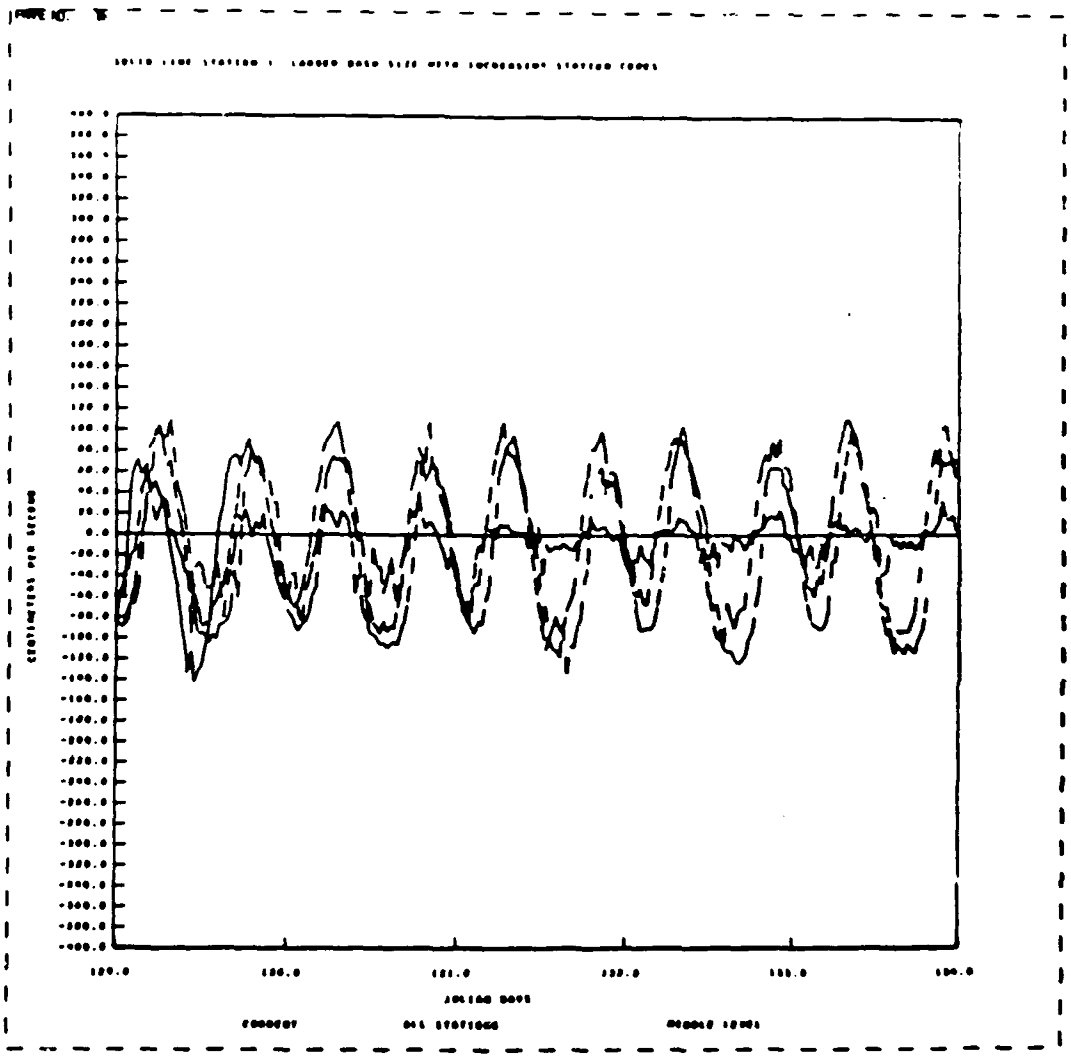


Figure 22. Microfiche Plot - Currents, Up and Down Channel, All Stations

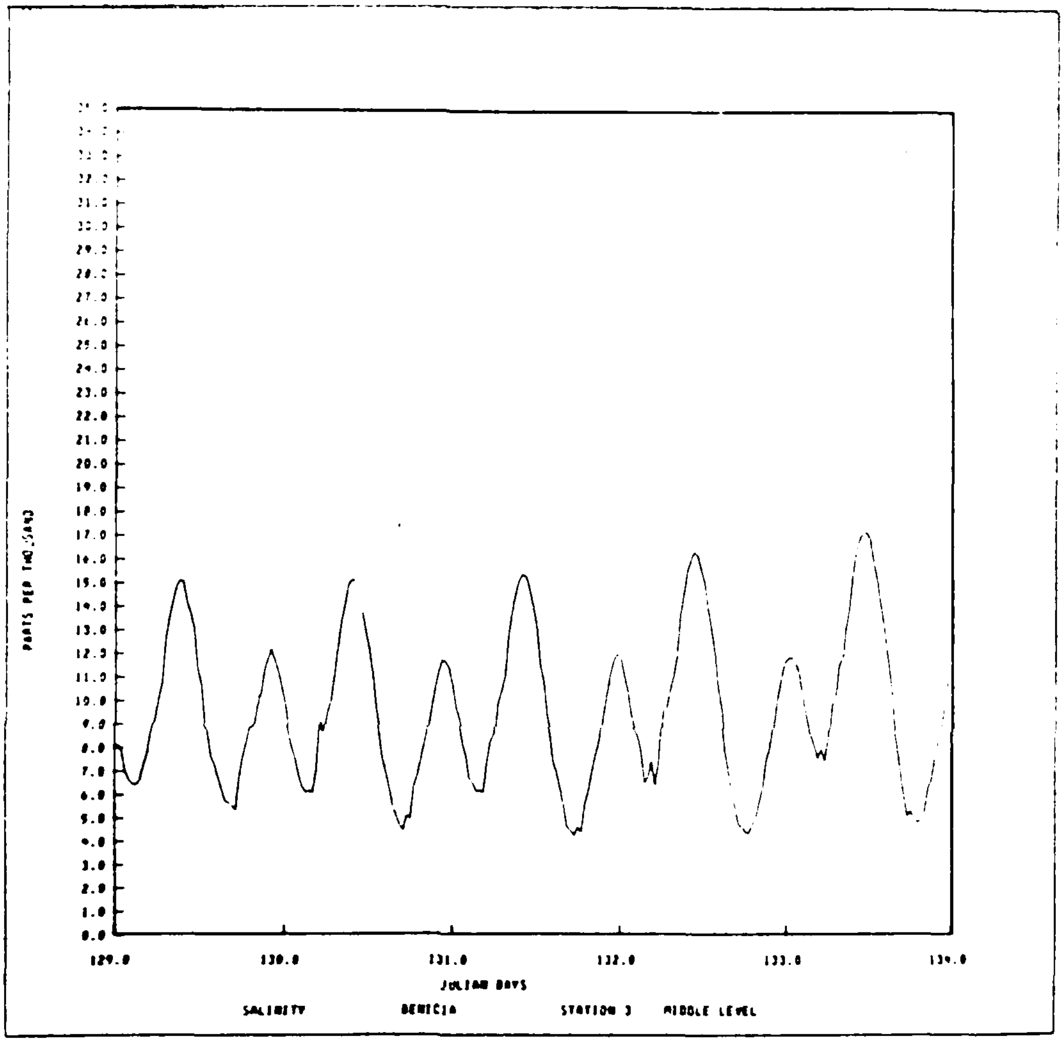


Figure 23. Microfiche Plot - Salinity, Mid Level, Benicia

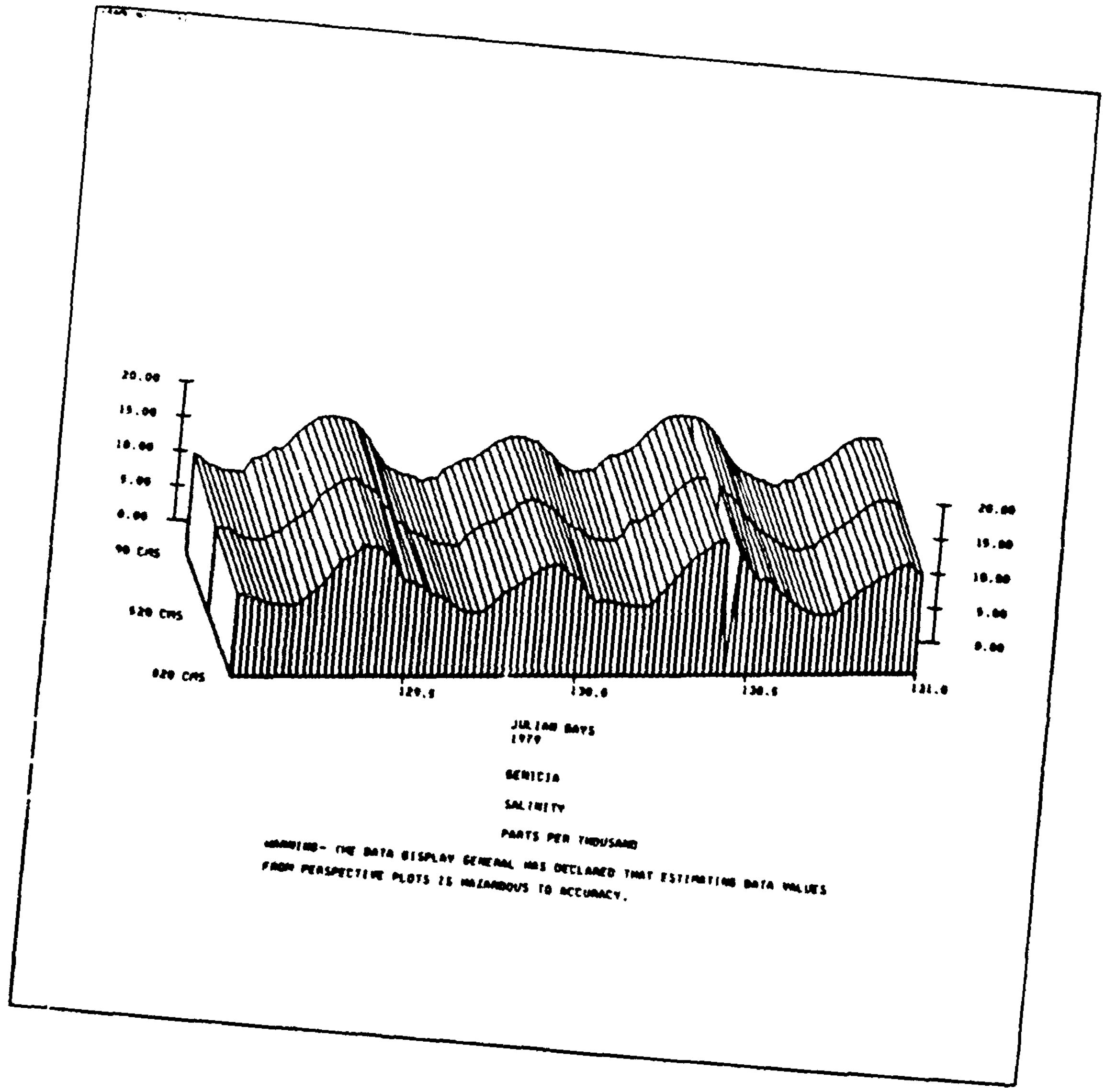


Figure 24. Microfiche Plot - Salinity, All Levels, Benicia

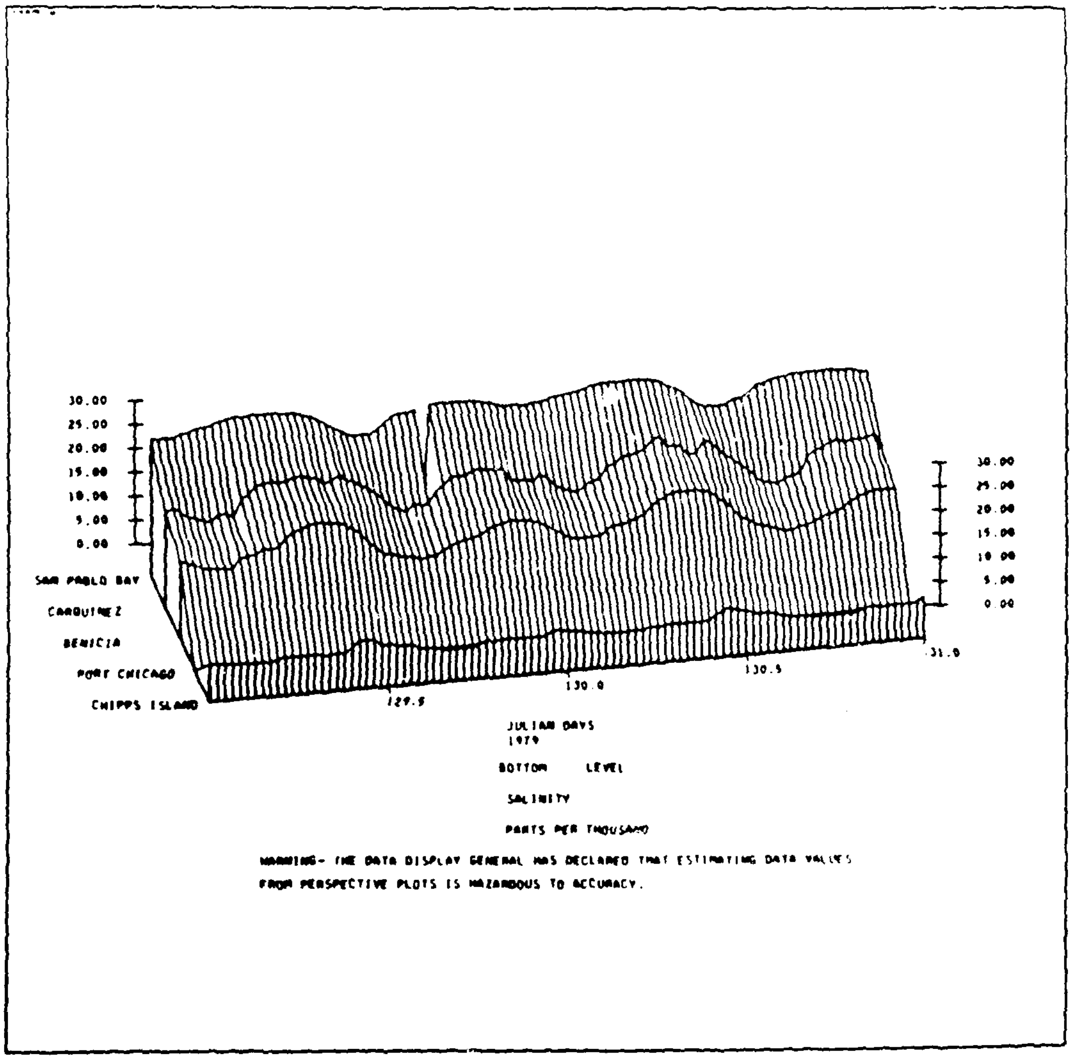


Figure 25. Microfiche Plot - Salinity, Bottom Level, All Stations

AD-A097 891 KINNETIC LABS INC SANTA CRUZ CA F/G 8/8
IN-SITU FIELD DATA GATHERING STATIONS, SAN FRANCISCO BAY-DELTA,--ETC(U)
MAR 81 DACW07-78-C-0049
UNCLASSIFIED KLI-81-1 NL

2
AD
A097891

END
DATE
FILMED
5 81
DTIC

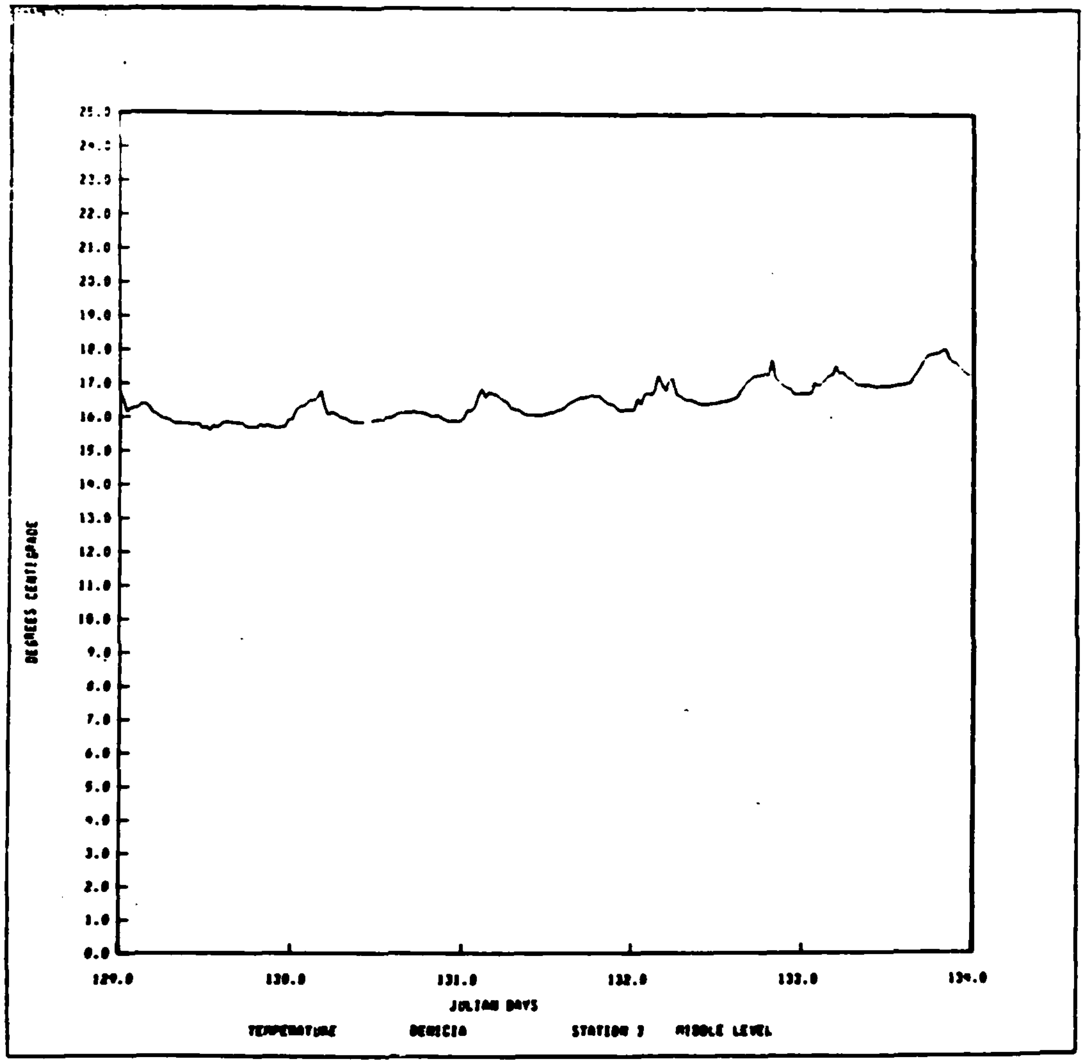


Figure 26. Microfiche Plot - Temperature, Mid Level, Benicia

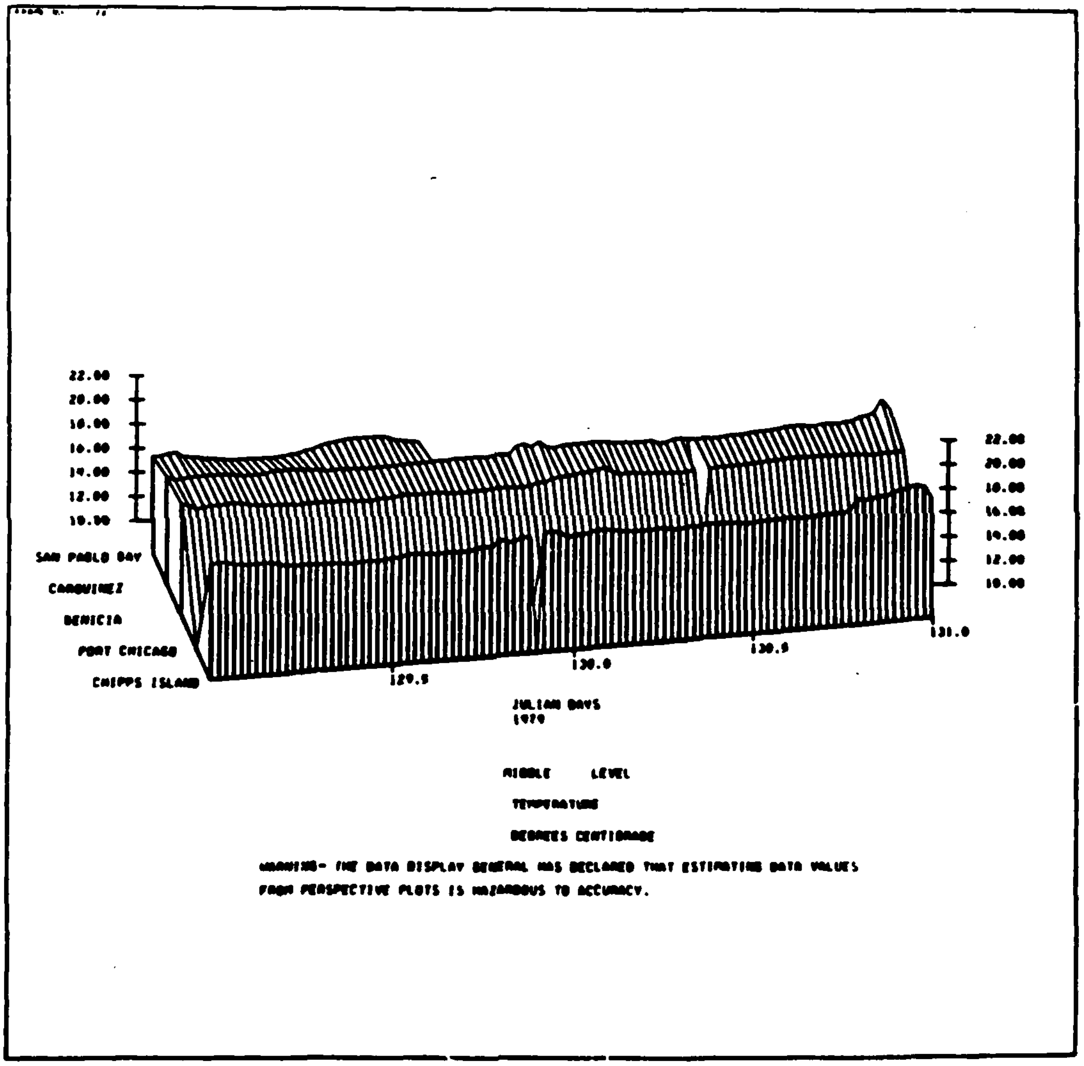


Figure 27. Microfiche Plot - Temperature, Mid Level, All Stations

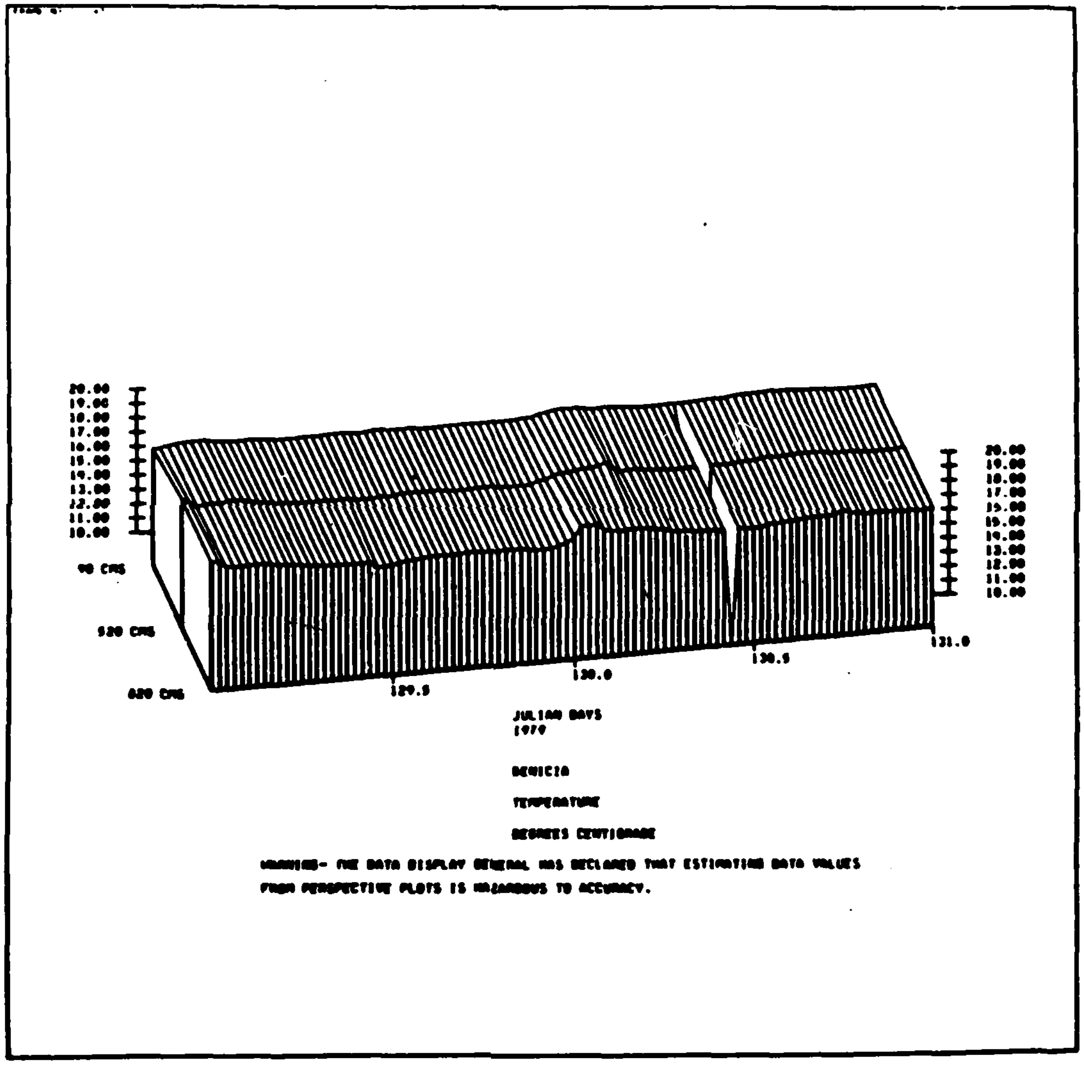


Figure 28. Microfiche Plot - Temperature, All Levels, Benicia

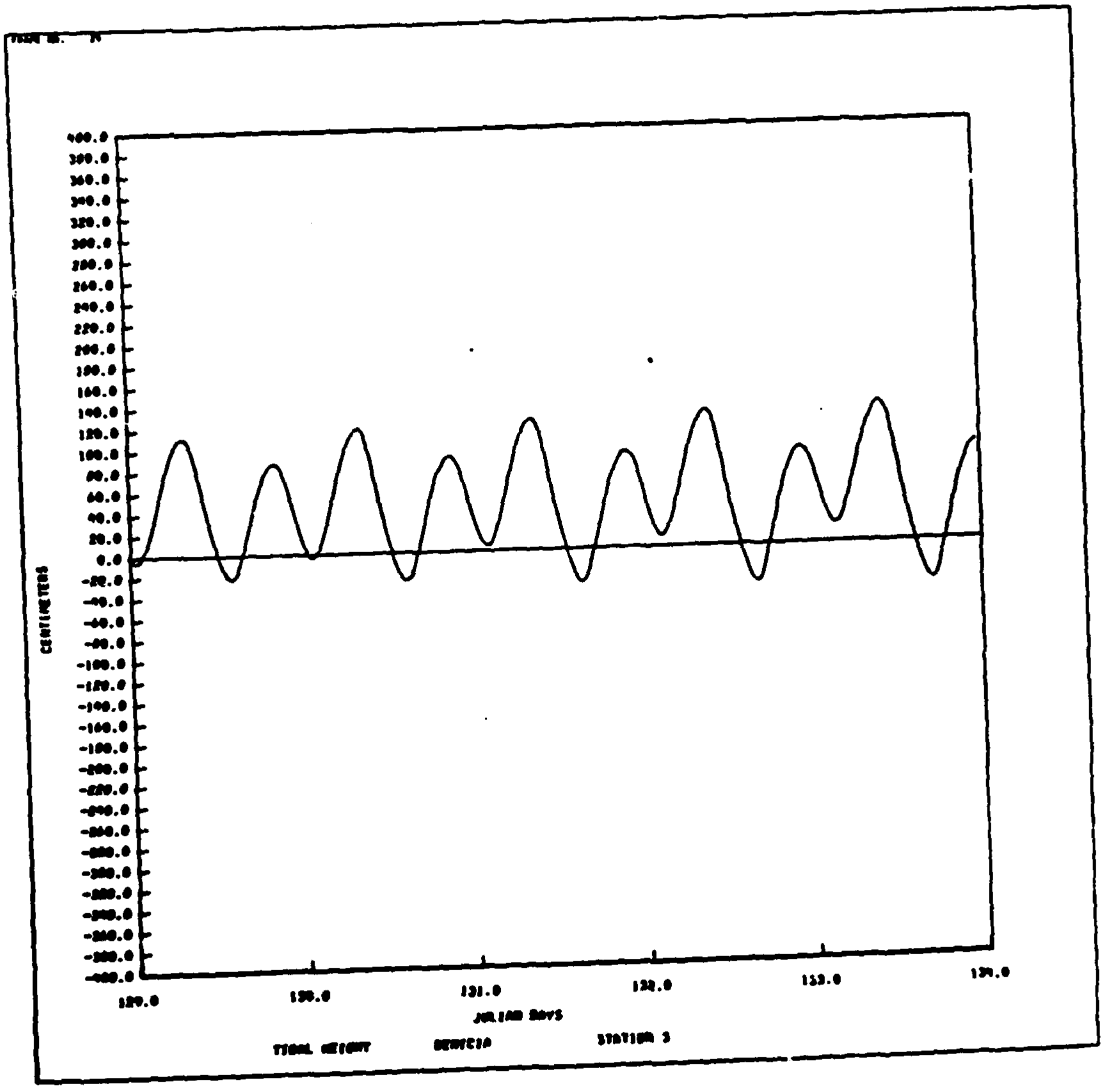


Figure 29. Microfiche Plot - Tidal Height, Benicia

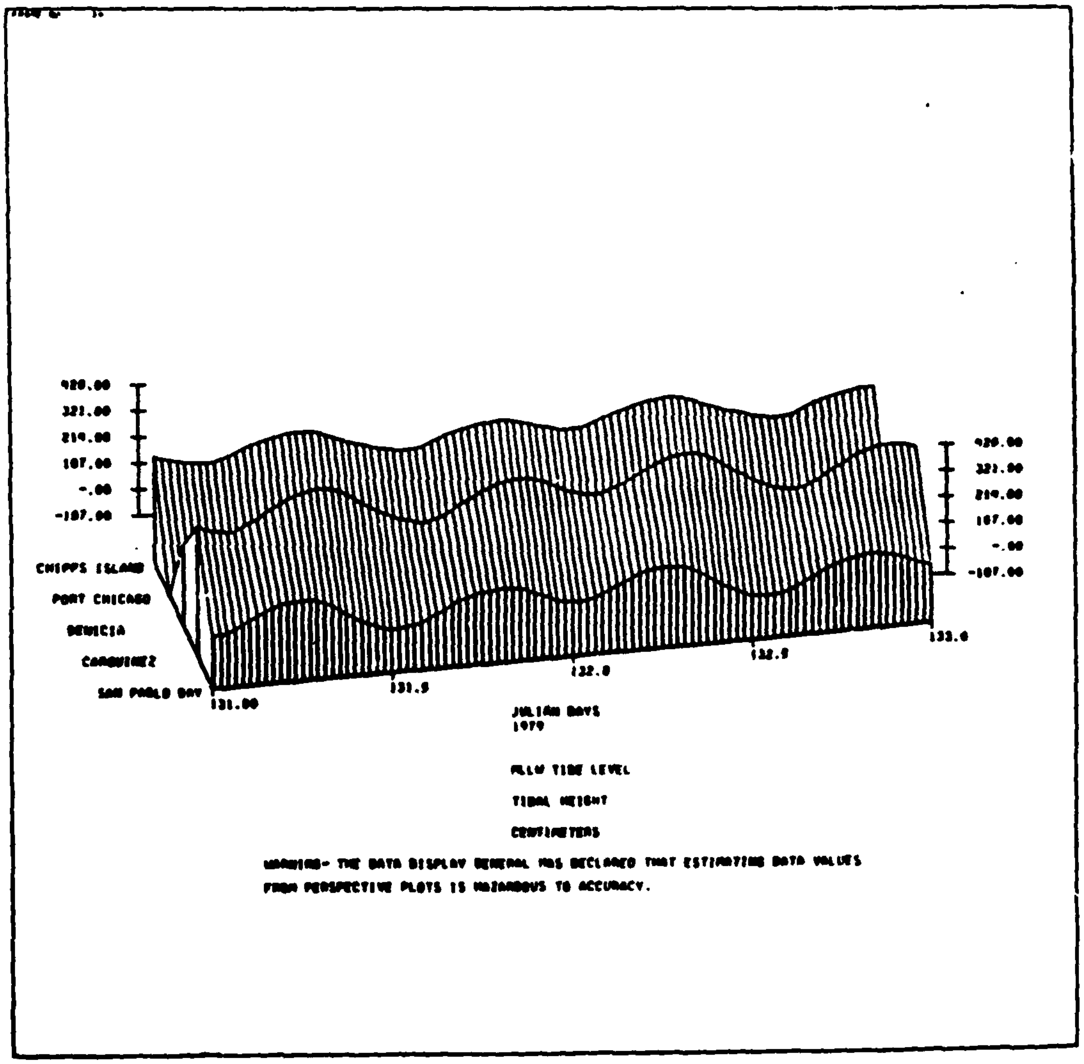


Figure 30. Microfiche Plot - Tidal Height, All Stations

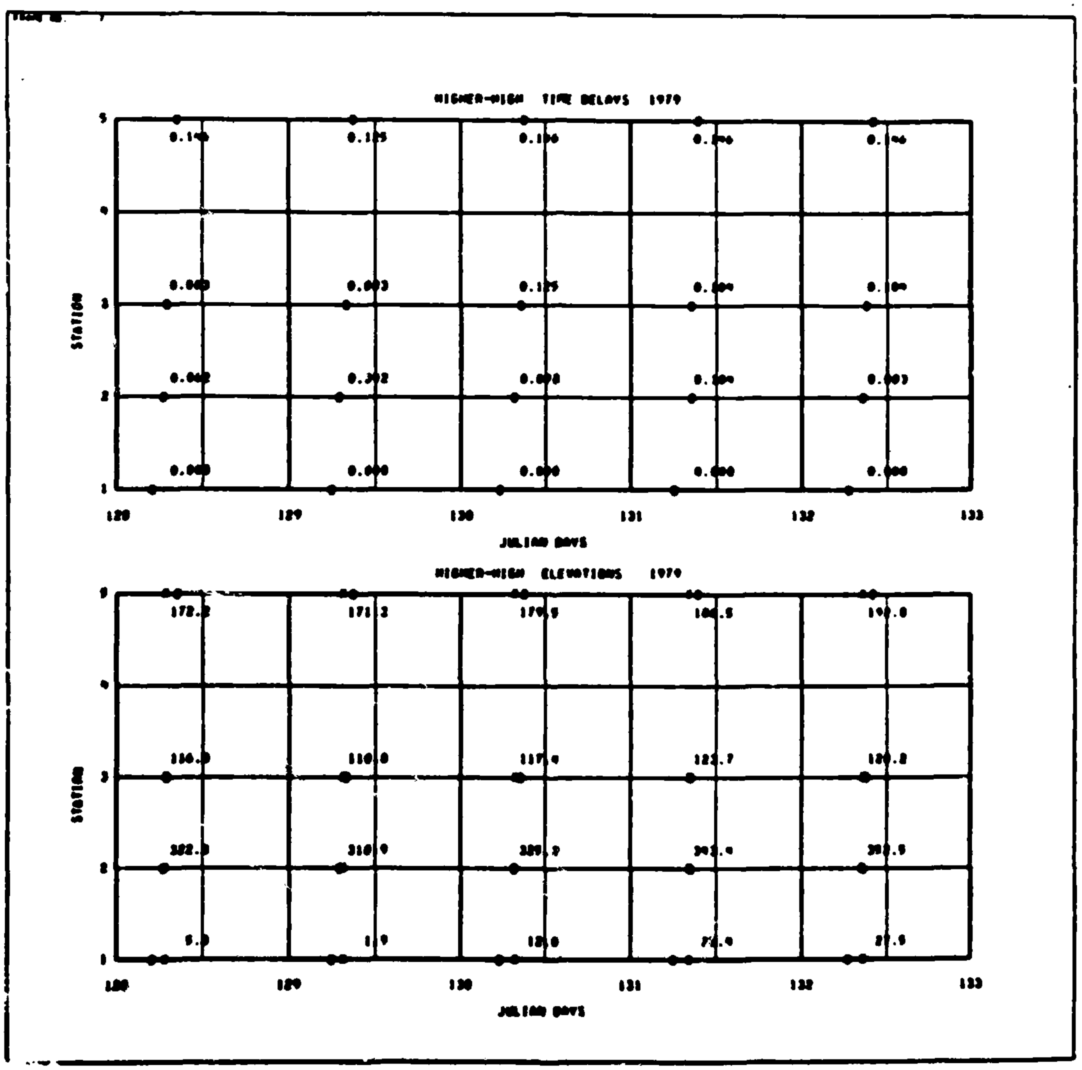


Figure 31. Microfiche Plot - Higher High Tides, Time Delays and Elevations

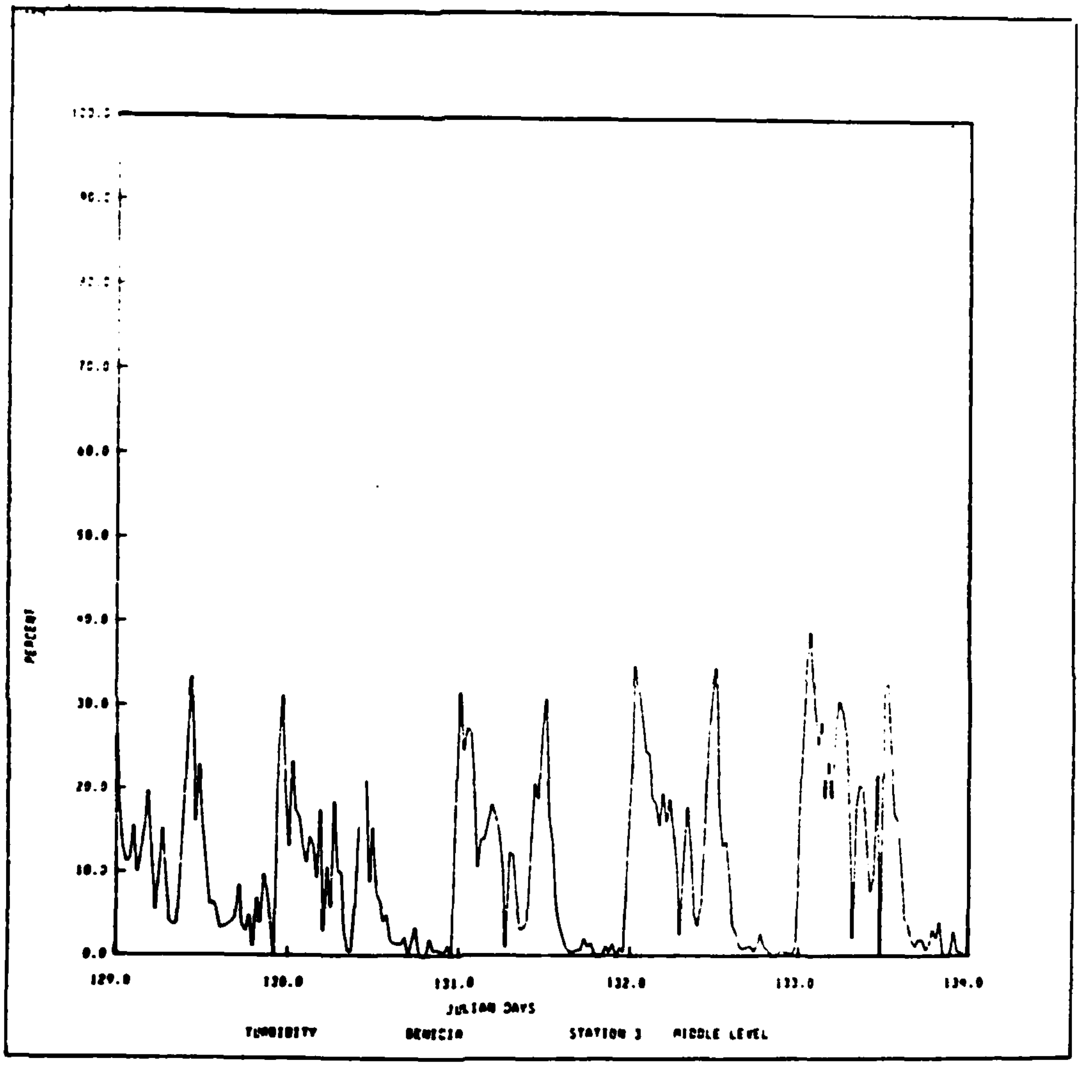


Figure 32. Turbidity, Mid Level, Benicia

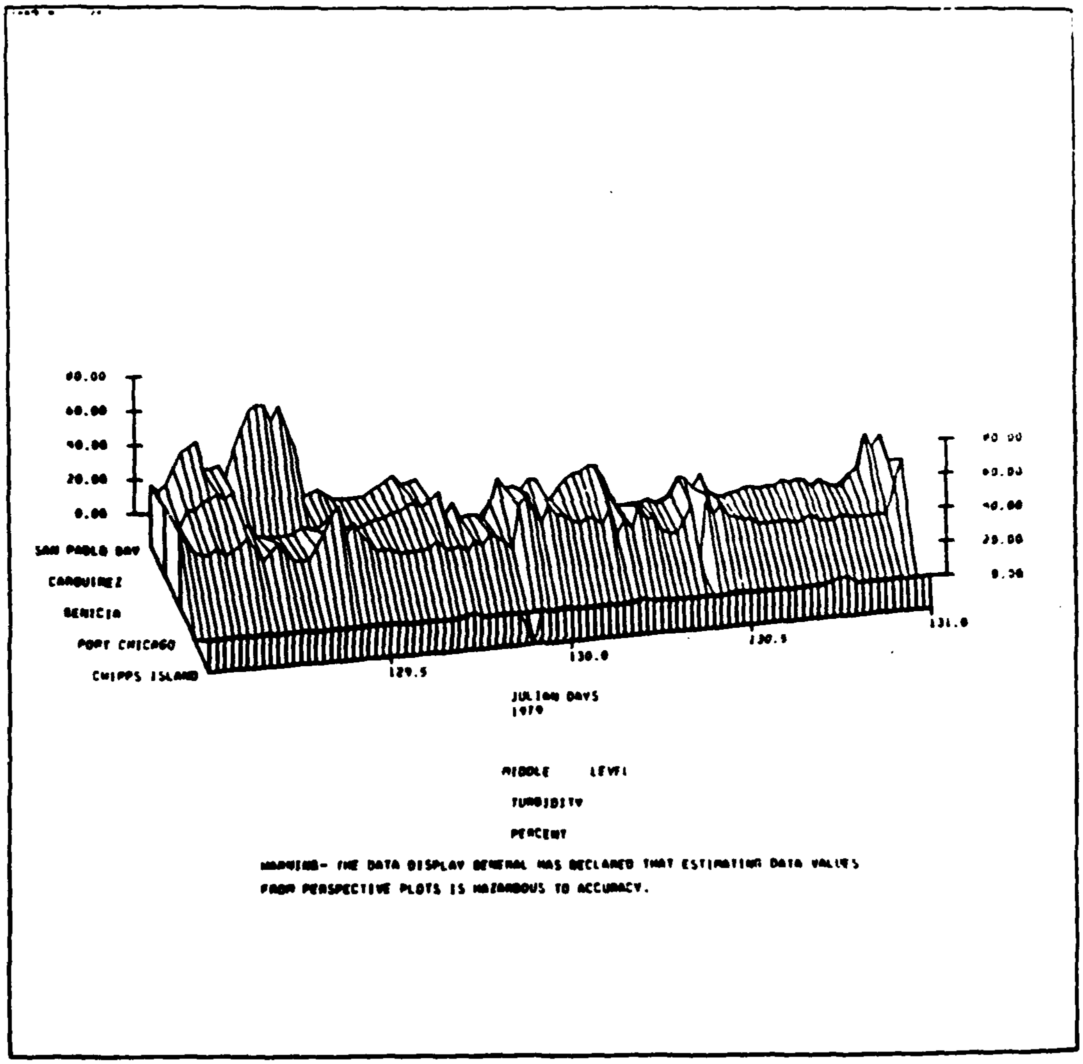


Figure 33. Microfiche Plot - Turbidity, Mid Level, All Stations

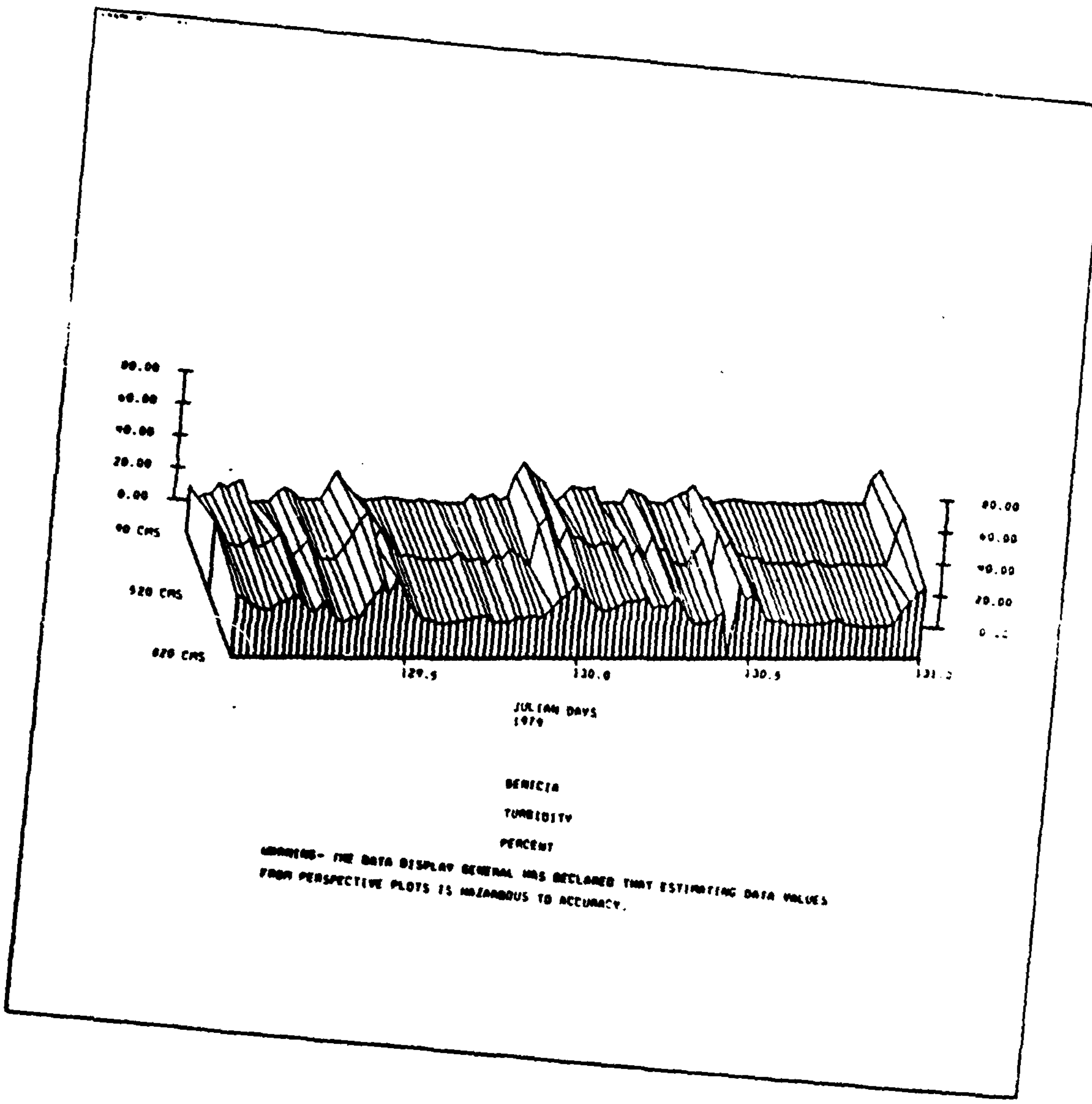


Figure 34. Microfiche Plot - Turbidity, All Levels, Benicia

Table 14. Catalog of Data Tapes

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0102.b	2030 39 1979	1700 59 1979	ce0x02.screen	8,9,14 February 1979 to 19,20 March 1979
2	0130 46 1979	1800 59 1979		
3	2130 40 1979	1900 59 1979		
4	2200 45 1979	1930 59 1979		
5	2100 45 1979	2000 59 1979		
6	0100 41 1979	2100 59 1979		
ce0103.a	1730 59 1979	2030 78 1979		
2	1830 59 1979	0030 79 1979		
3	1930 59 1979	1630 79 1979		
4	2000 59 1979	1730 79 1979		
5	2030 59 1979	1830 79 1979		
6	2130 59 1979	2030 79 1979		
ce0103.b	2230 78 1979	1700 94 1979	ce0x03.screen	19,20 March 1979 to 19,20 April 1979
2	0200 79 1979	1800 94 1979		
3	1700 79 1979	1900 94 1979		
4	1830 79 1979	2000 94 1979		
5	1900 79 1979	2030 94 1979		
6	2100 79 1979	2130 94 1979		
ce0104.a	1730 94 1979	1830 109 1979		
2	1830 94 1979	2300 109 1979		
3	1930 94 1979	1630 110 1979		
4	2030 94 1979	2300 110 1979		
5	2100 94 1979	2030 110 1979		
6	2200 94 1979	0230 111 1979		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0104.b	2030 109 1979	1600 122 1979	ce0x04.screen	19,20 April 1979 to 17,18 May 1979
2	0130 110 1979	1700 122 1979		
3	1830 110 1979	1800 122 1979		
4	0100 111 1979	1900 122 1979		
5	2130 110 1979	2000 122 1979		
6	0300 111 1979	2100 122 1979		
ce0105.a	1630 122 1979	1500 138 1979		
2	1730 122 1979	1630 137 1979		
3	1830 122 1979	2130 137 1979		
4	2000 122 1979	2300 137 1979		
5	2030 122 1979	0100 138 1979		
6	2130 122 1979	0200 138 1979		
ce0105.b	1530 138 1979	1600 151 1979	ce0x05.screen	17,18 May 1979 to 13,14,15 June 1979
2	1930 137 1979	1700 151 1979		
3	2200 137 1979	1800 151 1979		
4	0100 138 1979	1900 151 1979		
5	0130 138 1979	2030 151 1979		
6	0230 138 1979	2130 151 1979		
ce0106.a	1630 151 1979	1300 166 1979		
2	1730 151 1979	1630 164 1979		
3	1830 151 1979	1930 164 1979		
4	2000 151 1979	1700 165 1979		
5	2100 151 1979	0100 165 1979		
6	2200 151 1979	1800 165 1979		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0106.b	1330 166 1979	1600 178 1979	ce0x06.screen	13,14,15 June 1979 to 13,17,18 July 1979
2	1830 164 1979	1730 178 1979		
3	2200 164 1979	1830 178 1979		
4	1730 165 1979	2100 178 1979		
5	0200 165 1979	2130 178 1979		
6	1830 165 1979	2230 178 1979		
ce0107.a	1630 178 1979	1730 198 1979		
2	1800 178 1979	2300 198 1979		
3	1900 178 1979	1700 194 1979		
4	2130 178 1979	2300 194 1979		
5	2200 178 1979	1630 199 1979		
6	2300 178 1979	2100 199 1979		
ce0107.b	2000 198 1979	1630 218 1979	ce0x07.screen	13,17,18 July 1979 to 22,23 August 1979
2	2330 198 1979	1800 218 1979		
3	2200 194 1979	2200 218 1979		
4	0230 195 1979	0100 219 1979		
5	2000 199 1979	2330 218 1979		
6	2330 199 1979	0430 219 1979		
ce0108.a	1700 218 1979	1900 234 1979	(note: raw data from 2000 198 1979 to 2330 234 1979 were included in ce0107.screen)	
2	2030 218 1979	2330 234 1979		
3	2230 218 1979	1600 235 1979		
4	0330 219 1979	0200 236 1979		
5	0030 219 1979	2300 235 1979		
6	0500 219 1979	2000 235 1979		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0108.b	2030 234 1979 (screened 0000 235)	1630 160 1979	ce0x08.screen	22,23 August 1979 to 2,3 October 1979
2	0000 235 1979	1730 260 1979		
3	1800 235 1979	0030 261 1979		
4	0230 236 1979	2000 260 1979		
5	0030 236 1979	2230 260 1979		
6	2130 235 1979	2330 260 1979		
ce0109.a	1700 260 1979	1730 275 1979		
2	1800 260 1979	1930 275 1979		
3	0100 261 1979	1900 276 1979		
4	2030 260 1979	2130 275 1979		
5	2300 260 1979	2300 275 1979		
6	0000 261 1979	1730 276 1979		
---calibration period---				
ce0111.a	0300 307 1979	0030 332 1979	ce0x11.screen	2,6 November 1979 to 27,28 November 1979
2	0100 307 1979	2330 331 1979		
3	2100 306 1979	2230 331 1979		
4	2330 306 1979	2300 332 1979		
5	1830 306 1979	1800 331 1979		
6	2030 310 1979	0030 333 1979		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0111.b	0100 332 1979	1830 345 1979	ce0x12.screen	27,28 November 1979 to 31 December 1979
2	0000 332 1979	1800 338 1979	(Note: raw data for all stations to 2330 365 1979 was included in ce0x12.screen files)	
ce0211.bb	1830 338 1979	2200 345 1979		
3	2300 331 1979	2330 345 1979		
4	2330 332 1979	1900 346 1979		
5	2030 331 1979	1930 346 1979		
6	0100 333 1979	2100 346 1979		
ce0112.a	1900 345 2979	2100 361 1979		
2	2230 345 1979	2230 361 1979		
3	0000 346 1979	1930 361 1979		
4	1930 346 1979	2230 360 1979		
5	2030 346 1979	2100 360 1979		
6	2130 346 1979	1900 360 1979		
ce0113.a	2130 361 1979	1930 10 1980	ce0x13.screen	1 January 1980 to 29, 30 January 1980
2	2300 361 1979	2100 10 1980		
3	2000 361 1979	2200 10 1980		
4	1830 361 1979	2300 10 1980		
5	2130 360 1979	0100 11 1980		
6	2000 360 1979	0200 11 1980		
ce0113.b	2000 10 1980	vandalized		
2	2130 10 1980	2000 29 1980		
3	2230 10 1980	2230 29 1980		
4	0100 11 1980	2100 30 1980		
5	0130 11 1980	1800 30 1980		
6	0230 11 1980	2000 30 1980		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0114.a	---	---	ce0x14.screen	29,30 January 1980 to 26,27 February 1980
2	2030 29 1980	1730 45 1980		
3	2300 29 1980	1900 45 1980		
4	0000 31 1980	2000 45 1980		
5	1830 30 1980	2100 45 1980		
6	2030 30 1980	2200 45 1980		
ce0114.b	---	---		
2	1800 45 1980	2200 57 1980		
3	1930 45 1980	2000 58 1980		
4	2030 45 1980	1830 58 1980		
5	2130 45 1980	1730 58 1980		
6	2230 45 1980	2230 58 1980		
ce0115.a	---	---	ce0x15.screen	26,27 February 1980 to 21,25 March 1980
2	0030 58 1980	1700 72 1980		
3	2000 58 1980	1800 72 1980		
4	---	---		
5	1800 58 1980	2230 72 1980		
6	2300 58 1980	2330 72 1980		
ce0115.b	---	---		
2	1730 72 1980	2330 85 1980		
ce0315.b1	1900 72 1980	2230 79 1980		
ce0315.b2	0100 80 1980	1900 85 1980		
4	2030 72 1980	2030 85 1980		
5	2300 72 1980	2130 85 1980		
6	0000 73 1980	1700 85 1980		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0116.a	0030 81 1980	1630 101 1980	ce0x16.screen	21,25 March 1980 to 28,30 April 1980
2	0000 86 1980	1730 101 1980		
3	2000 85 1980	1830 101 1980		
4	2100 85 1980	1930 101 1980		
5	2200 85 1980	2030 101 1980		
6	1730 85 1980	2230 101 1980		
ce0116.b	1700 101 1980	1600 121 1980		
2	1800 101 1980	2100 119 1980		
3	1900 101 1980	2030 121 1980		
4	2000 101 1980	2300 121 1980		
5	2100 101 1980	2330 121 1980		
6	2300 101 1980	0030 122 1980		
ce0117.a	---	---	ce0x17.screen	28,30 April 1980 to 2 June 1980
2	2130 119 1980	2100 137 1980		
3	2100 121 1980	1730 140 1980		
4	2330 121 1980	0030 138 1980		
5	0000 122 1980	0000 138 1980		
6	0100 122 1980	2300 137 1980		
ce0117.b	---	---		
2	2130 137 1980	1500 154 1980		
3	1830 140 1980	1600 154 1980		
4	0130 138 1980	1700 154 1980		
5	0030 138 1980	1800 154 1980		
6	2330 137 1980	1900 154 1980		

Table 14. Catalog of Data Tapes (continued)

Raw Data Cassette Tape Identifying Label/Raw Data Filename	Field Start Time (Greenwich Mean Time, Julian Day, Year)	Field End Time (Greenwich Mean Time, Julian Day, Year)	Reduced (Screened) Data Tape Identifying Label/Reduced (Screened) Data Filename Format	Approximate Calendar Time Period
ce0118.a	---	---	ce0x18.screen	2 June 1980 to 2,3 July 1980
2	1530 154 1980	1500 172 1980		
3	1630 154 1980	1300 172 1980		
4	1730 154 1980	2330 171 1980		
5	1700 155 1980	2200 171 1980		
6	1930 154 1980	2030 171 1980		
ce0118.b1	2100 172 1980	1730 176 1980		
ce0118.b2	1800 176 1980	1730 184 1980		
2	1530 172 1980	2000 184 1980		
3	1400 172 1980	2300 184 1980		
4	0000 172 1980	2230 185 1980		
5	2230 171 1980	2000 185 1980		
6	2100 171 1980	0130 185 1980		

RECOMMENDATIONS

In order to ensure continuous data collection with as few interruptions as possible, it was necessary that the instrumentation in the field be kept operational. Due to the high failure rates experienced and the limited number of spares available, the mechanics of field operations occupied a substantial portion of project efforts. Our ability to perform preventive maintenance, special studies on sensor performance, and instrument check-out was severely limited because all spares (and often some station instruments) were either undergoing emergency repair or being immediately rotated back into the field as replacements for newly failed instruments.

At the beginning of the program it was assumed that the major problems would be in successfully mooring the instrumentation, considering the adverse environmental conditions and the possibility of vandalism. However, the mooring efforts proved to be very successful, and it was, instead, the abnormally high instrument failure rate that presented the major problem.

The data processing scheme followed that of the original project specifications. Emphasis was thus on producing monthly 9-track data tapes and three-dimensional data plots, with all data interpretation left to later users. Difficulties in time sequencing of resulting data (due to interrupts in the cassette recording system, along with frequent field substitution of instruments) considerably complicated and slowed monthly data turnaround. Detection of additional instrument problems not apparent from field check procedures was also delayed.

If additional data collection efforts are attempted under this program, the following recommendations are made in order to improve the amount and quality of the data obtained.

Instrumentation

Obviously, instrumentation reliability must be improved to ensure increased quality and quantity of future data recovery. Because of a large existing investment in present instrument systems, the only practical approach is to utilize these instruments and put additional efforts into increasing their reliability.

First of all, there should be a careful evaluation of the component systems with respect to reliability, from an engineering as well as an operational viewpoint. Since all

sensors or components were not equally prone to failure, efforts would be focused on those priority items which caused the most serious problems and also on those for which practical solutions can be devised.

For example, the frequent recorder failures, resulting in tape interrupts and sometimes complete failure to record station data, were responsible for the greatest percentage of data loss. Obviously, efforts to solve these problems should be a priority. However, problems in other systems are often related. For example, cable failures, particularly the turbidity sensor cables, often drained recorder battery life such that a complete failure to record all station data occurred. Time clock problems also slowed data recovery. Accurate time keeping by these clocks would allow computer rather than manual checking of data time sequences, thus alleviating many of the data interrupt problems.

Another priority item is that of depth sensor performance. Failure (usually leakage) of sensors, major drift in calibrations, and apparent long response time problems need attention. Tests to determine the sources of these problems and to define methods of fixing these defects are needed so that reliable and accurate tidal data can be obtained.

Conductivity, temperature, and current sensors in general performed much more satisfactorily than other sensors. Effort here should be directed toward trying to reduce the failures of these sensors due to component malfunctions.

Data Processing

The data management scheme presently implemented seems to work quite adequately when the hardware is functioning well. Hardware problems generally slow down data "production" significantly. This results primarily from the system being designed around the sampling hardware specifications from the manufacturer.

Once the data are in "standard file form," i.e., on GSS files at LBL, the processing procedures are straightforward. However, preliminary to preparing those files, we have encountered difficulties which slow down production. Most of these difficulties are inherent in the basic design of the software system which reflects the original specifications for data processing as well as normal equipment performance expectations. The present system does, however, rely strongly on interactive processing without which processing the data would be virtually impossible due to the variety of data problems which we have encountered.

Data management could be substantially enhanced if the following modifications were implemented:

1. Change "monthly" orientation to "cassette" orientation. Extensive file management is required to sample and process data on a monthly schedule. By the simple expedient of creating "ghost" GSS files of missing data, these previously created data files can be modified (i.e., filled) with "non-missing" data as they are collected. Therefore, no monthly scheduling is necessary and data may be handled in the most "natural" unit---the cassette file.

   Enter into production with interactive data plotting of the raw data. We have already designed software which will plot averaged data from a sensor package. We have not implemented this phase since it is labor intensive and tends to duplicate (computationally) operations performed by later screening programs. We think that use of this step is important for turning around information rapidly on the performance of a sensor package. Naturally "turnaround" of these plots would be enhanced by data files being shorter (i.e., one cassette's worth, not two). We would also modify this existing software to do the major <u>screening</u> and <u>array assembly</u> (for LBL GSS files). By this latter expedient, we would short-cut a substantial body of procedures. This would also clearly delimit the respective realms of interactive/batch environments. Note that there would be a shift of user labor from batch processing to interactive. We see this as a positive step because the production of interactive plots would be an invaluable biproduct, since having the data quickly displayed in time series graphics is the most efficient means of discerning subtle hardware problems.

   An addition to the presently designed (but not implemented) interactive plot program is required to use it as a screen and array assembler. Routines for creating, managing and filling GSS files at LBL are also required.

Were a redesign of the clocks deemed feasible, additional interactive software to help automate the sequencing of data records would be indicated.

<u>Field/Laboratory Operations</u>

In addition to sensor failures in the field, experience has shown that sensors can give spurious values that are not detected during regular field servicing (e.g., deck readout

may signal a strong bottom current yet actual verification would require lowering a duplicate instrument package). Present ground-truth measurements have consisted of simple instrument readings, usually at the surface only. A second characteristic of present operations was to leave instruments deployed in the field until failure occurred.

If instrument reliability can be increased to the point that spares are actually available, then much improved operational procedures can be implemented. This effort should be given priority consideration. First of all, a regular schedule of rotating instruments back to the laboratory for functional checks and for calibration checks could be implemented. Preventive maintenance should reduce failures somewhat, and regular calibrations would increase confidence in the accuracy of sensor readings and detect drifting or spurious readings. As a secondary measure (because of on-station time restrictions), some additional ground-truth measurements at depth could be added.

Boat positioning and on-station operations were difficult in the fast current regimes encountered, but satisfactory and safe procedures were worked out. Minor modifications to mooring equipment are recommended for convenience and to ease somewhat the physically demanding aspects of the station servicing. However, the major recommended change would be the use of a high pressure water spray device to clean summer fouling.

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